

## APPENDIX - CI

### **MADURAI KAMARAJ UNIVERSITY** *(University with Potential for Excellence)*

#### **M.Sc. Microbiology (SEMESTER)**

#### **SYLLABUS**

*(Effect from the academic year 2023 onwards)*

#### **SCHEME OF EXAMINATIONS AND REGULATIONS**

##### **1. Introduction of the program**

This two year Masters of Science course in Microbiology deals with the advanced study of microorganisms comprising Bacteria, Fungi, Protozoans, Algae and Virus; and its association with the environment, plants, animals and humans. Candidates undertaking this curriculum will understand the advanced concepts of Microbiology including the benefits and harmful role of microorganisms in the production of commercially important products and in various diseases respectively. Concepts of Biotechnology and concepts of food microbiology included in this curriculum will help them in the future to face various industries. Host pathogen interactions noticed in the plant and the animal system is also included in the syllabus at the in-depth level, which will make them understand about various diseases and its treatment.

##### **2. Eligibility for admission:**

A candidate with 55% total aggregate in B.Sc. in Microbiology / Bio-Chemistry / Botany / Zoology / Biotechnology / Agriculture / B.Tech. in Biotechnology or any other relevant life science degree is eligible.

A candidate with 55% total aggregate in B.Pharm. / B.V.Sc. / M.B.B.S may also be considered for admission.

However the candidate should have undergone Higher Secondary examination (10+2) conducted by the Board of Higher Secondary Education, Govt. of Tamil Nadu or any other examinations accepted as Equivalent thereto by the syndicates subject to such conditions

- a) Biology/Physics/Chemistry as subjects in the Higher Secondary education.
- b) Candidates should have secured at least 60% in the above subjects individually and as total aggregates

A relaxation of 10% marks in the aggregate shall be given to SC/ST/Physically Challenged candidates.

### 2.1. Duration of the programme

The students will undergo the prescribed course of study for a period of not less than two academic years (four semesters)

The maximum duration for completion of the PG Programme shall not exceed eight semesters.

### 2.2. Medium of Instructions of the programme: English

## 3. Objectives of the Programme

- To provide value based education, with academic excellence and advanced research.
- To inculcate the advanced concepts of Microbiology including taxonomy, physiology, Immunology, biomolecular interactions, genomics, proteomics and rDNA technology.
- To impart the scope for the application of concepts learned in the subject.
- To introduce about the recent advances in the field of Microbiology and its importance in research.
- To raise skilled candidates with research caliber in the field of Microbiology

## 4. Outcome of the Programme

The scope of this course is wide which enables the candidate to get placed in diagnostics, pharma, fermentation, dairy, food and medical arena. This course also involves individual project dissertation work which enables the candidate to carry out independent research and make them understand all the troubleshoot in various experiments.

## 5. Core subject papers

|                                                                                                |
|------------------------------------------------------------------------------------------------|
| General Micro Biology, Cell Biology & Biochemistry, Agricultural & Environmental Microbiology, |
| Immunology, Molecular biology & Microbial Genetics, Fermentation Technology,                   |
| Microbial Bioremediation, Genetic Engineering, Bioinformatics                                  |
| Research Methodology, Project and Viva – voce                                                  |

## 6. Subject elective papers

Medical Microbiology

Genomics & Proteomics

## 7. Non-subject elective papers

Applied Microbiology

## 8. Unitization

| Subject code | Title of the Paper | Weekly contact hours | No. of credits | Examination Hours | Marks |
|--------------|--------------------|----------------------|----------------|-------------------|-------|
|--------------|--------------------|----------------------|----------------|-------------------|-------|

|  |                                           |           |           |   | Int. | Ext. | Total      |
|--|-------------------------------------------|-----------|-----------|---|------|------|------------|
|  | <b>I Semester</b>                         |           |           |   |      |      |            |
|  | General Micro Biology                     | 6         | 6         | 3 | 25   | 75   | 100        |
|  | Cell Biology & Biochemistry               | 6         | 6         | 3 | 25   | 75   | 100        |
|  | Agricultural & Environmental Microbiology | 6         | 6         | 3 | 25   | 75   | 100        |
|  | Practical – I                             | 6         | 3         | 6 | 40   | 60   | 100        |
|  | Medical Microbiology (T&P)                | 6         | 4         | 3 | 25   | 75   | 100        |
|  | <b>Total</b>                              | <b>30</b> | <b>25</b> |   |      |      | <b>500</b> |
|  | <b>II Semester</b>                        |           |           |   |      |      |            |
|  | Immunology                                | 6         | 6         | 3 | 25   | 75   | 100        |
|  | Molecular biology & Microbial Genetics    | 6         | 6         | 3 | 25   | 75   | 100        |
|  | Fermentation Technology                   | 6         | 6         | 3 | 25   | 75   | 100        |
|  | Practical – II                            | 6         | 3         | 6 | 40   | 60   | 100        |
|  | Applied Microbiology                      | 6         | 4         | 3 | 25   | 75   | 100        |
|  | <b>Total</b>                              | <b>30</b> | <b>25</b> |   |      |      | <b>500</b> |
|  | <b>III Semester</b>                       |           |           |   |      |      |            |
|  | Genomics & Proteomics (T&P)               | 6         | 4         | 3 | 25   | 75   | 100        |
|  | Microbial Bioremediation                  | 6         | 6         | 3 | 25   | 75   | 100        |
|  | Genetic Engineering                       | 6         | 6         | 3 | 25   | 75   | 100        |
|  | Bioinformatics                            | 6         | 6         | 3 | 25   | 75   | 100        |
|  | Practical – III                           | 6         | 3         | 6 | 25   | 75   | 100        |

|  |                         |           |           |   |    |    |             |
|--|-------------------------|-----------|-----------|---|----|----|-------------|
|  | <b>Total</b>            | <b>30</b> | <b>25</b> |   |    |    | <b>500</b>  |
|  | <b>IV Semester</b>      |           |           |   |    |    |             |
|  | Research Methodology    | 5         | 5         | 3 | 25 | 75 | 100         |
|  | Project and Viva – voce | 25        | 10        |   | 20 | 80 | 100         |
|  | <b>Total</b>            | <b>30</b> | <b>15</b> |   |    |    | <b>200</b>  |
|  | <b>Grand Total</b>      |           | <b>90</b> |   |    |    | <b>1700</b> |

## 9. Pattern of semester exam

### THEORY QUESTION PAPER PATTERN

Time: 3 hours

Max Marks: 75

*Section A: (10 x 1 = 10 Marks) (Answer all the Question; 1 to 10)*

Question No 1 to 10

1. Two questions from each unit.
2. Four choices in each question.
3. Answer all questions. Choose the right answer.

*Section B: (5 x 7 = 35 marks)*

Answer all questions - Either Or types

Answer not exceeding two pages. (One question from each unit) **Question Nos.**

11a or 11b  
12a or 12b  
13a or 13b  
14a or 14b  
15a or 15b

*Section C: (3 x 10 = 30 marks)*

Answers not exceeding four pages

Answers any **THREE** out of Five (one question from each unit)

Question Nos.- 16-20

## PRACTICAL QUESTION PAPER PATTERN

Time: 6 Hours

Maximum Marks (University Exam) - 60

|                      |            |
|----------------------|------------|
| One Major Experiment | = 20 marks |
| One Minor Experiment | = 10 marks |
| Two spotters         | = 05 marks |
| Record Book          | = 05 marks |
| Viva Voce            | = 20 marks |

### Project evaluation: (MAX 100 Marks) External

#### *Maximum Mark (80 Marks)*

|                       |            |
|-----------------------|------------|
| Dissertation work     | = 60 marks |
| Presentation and viva | = 20 marks |

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80 Marks

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The candidate failing in any subject(s) will be permitted to appear for each failed subject(s) in the subsequent examinations. The practical examinations for UG course should be conducted at the end of the every semester.

### **10. Scheme for Internal Assessment**

#### For Theory papers

- |                                                 |            |
|-------------------------------------------------|------------|
| a) Two internal tests of 15 marks each: Average | = 15 marks |
| b) Group discussion/ Seminar/ Quiz              | = 05 marks |
| c) Two assignments: 5 marks each: Average       | = 05 marks |

#### For Practical papers

- |                                                          |            |
|----------------------------------------------------------|------------|
| a) Two internal tests of 25 marks each: average          | = 25 marks |
| b) Observation book                                      | = 10 marks |
| c) One assignment                                        | = 05 marks |
| d) Internal Marks for the project (decided by the guide) | = 20 marks |

### **11. External Exam**

Refer point 9.

## 12. Question paper pattern

Refer point 9.

## 13. Scheme for evaluation

### 14. Passing minimum

To get a pass, should fulfill the following conditions:

#### A) Theory:

1. 50% of the aggregate (External + Internal).
2. No separate pass minimum of internal
3. 38 marks out of 75 is the pass minimum for the External.

#### B) Practicals:

1. 50% of the aggregate (External + Internal)
2. No separate pass minimum for the internal
3. 30 marks out of 60 is the pass minimum for the External.

#### C) Project:

1. 50% of the aggregate (project evaluation + Viva-voce)
2. No separate pass minimum for the viva-voce
3. 40 marks out of 80 is the pass minimum for the project evaluation

### 14.1 Classification

| S. No | Range of CCPA           | Class |
|-------|-------------------------|-------|
| 1     | 50 & above but below 60 | II    |
| 2     | 60 & Above              | I     |

## 15. Model questions

### Section A

Answer all questions (10X1=10)

#### 1. According to Pasteur statements which one of the following is true

- a. Living organisms discriminate between stereoisomers
- b. Fermentation is a aerobic process
- c. Living organisms doesn't discriminate between stereoisomers
- d. Both a and b.

#### 2. Who demonstrated that open tubes of broth remained free of bacteria when air was free of dust.

- a. Abbc Spallanzani

- b. John Tyndall
- c. Francisco Redi
- d. Pasteur

*3. In electron microscope, what material is used as an objective lense?*

- a. Magnetic coils
- b. Superfine glass
- c. Aluminium foils
- d. Electrons

*4. Meosomes are also known as*

- a. Mitochondria
- b. Endoplasmic reticulum
- c. Plasmids
- d. Chondroids

*5. Term vaccine was coined by*

- a. Robert Koch
- b. Pasteur
- c. Needham
- d. None of these

*6. The mode of reproduction which occurs in mycoplasma is*

- a. Budding
- b. Bursting
- c. Binary fission
- d. Binary fusion

*7. The bacterial pili mainly contain*

- a. Carbohydrates
- b. Lipids
- c. Proteins
- d. Minerals

*8. Sulphur oxidizing bacteria is*

- a. Alcaligenes
- b. Pseudomonas
- c. Thiobacillus
- d. None of these

*9. beta haemolytic bacteria is*

- a. Streptococcus pyogenes
- b. Str. pneumoniae
- c. Str. viridans

d. Str. Faecalis

10. *Batch fermentation is also called*

- a. Closed system
- b. Open system
- c. Fed-Batch system
- d. Sub-merger system

*Section B:*

**Answer all questions (5 x 7 = 35 marks)**

11a. Write the contributions of Pasteur and Beijerinck.

Or

11b. Explain briefly the structure and functions of bacterial cell wall.

12a. Briefly explain the concept of containment facility.

Or

12b. Write a commonly used method for isolation of pure culture of bacterium.

13a. Distinguish between continuous and synchronous cultures.

Or

13b. Distinguish between bacteria and mycoplasmas.

14a. Give a brief account of slime molds.

Or

14b. Briefly explain the morphological features protozoa.

15a. Write a brief note on bioluminescence

Or

15b. Explain Calvin cycle

*Section C*

**Answer any three questions.(3X 10= 30)**

16. Give detail note on Bergy's system of bacterial classification

17. Discuss about early era of microbiology and major Scientist contributions

18. Explain about fungal classification

19. Describe the process of sporulation in *Bacillus*

20. Explain the microbes which live in extreme environments with suitable examples



## **16. Teaching methodology**

### **17. & 18. Text book & Reference books**

- 1) Prescott, Harley and Klein. 2006, Microbiology 6/e. The McGraw-Hill Companies.
- 2) Peleazar, M.J., Chan. E.C.S. and Kreig. N.R. 1993. Microbiology, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- 3) Schlegel. H.G. 1993. General Microbiology. Cambridge University Press, Cambridge.
- 4) Stainer. R.Y., Ingraham, Wheelis, M.G. and Paintor. P.R. 1986, The Microbial World, Prentice Hall, New Jersey.
- 5) Tauro. P., Kapoor, K.K. and Yadav. K.S. 1989, An Introduction to Microbiology, Wiley Publications. New Delhi.
- 6) Microbiology: A laboratory manual, P. Gunasekaran, New Age international publishers, 1996.
- 7) Laboratory manual in general microbiology, N. Kannan, Panima publishers, 2002.
- 8) Microbiology: A laboratory manual. J.G. Cappuccino and N. Sherman, Addison-Wesley, 2002.
- 9) Bergey's manual determinative bacteriology, J.G. Holt and N.R. Krieg. Lippincott Williams & Wilkin publishers, 2000.
- 10) Moat AG. Foster JW and Spector MP. Microbial Physiology. 4/e Wiley-Liss, 2002.
- 11) Prescott, Harley and Klein, Microbiology. 6/e The McGraw-Hill Companies, 2006.
- 12) Caldwell DR. Wm. Microbial physiology and metabolism. C Brown publishers, USA 2002.
- 13) J.C. Cappuccino and N. Sherman, Microbiology: A laboratory manual, Addison – Wesley, 2002.
- 14) M.T. Maigan, J.M. Martinko and J. Parkar, 2000. Brock Biology of Microorganisms, (9<sup>th</sup> edition), Prentice-Hall.
- 15) C.J. Alexopoulos and C.W. Mims 1979, Introductory Mycology (3<sup>rd</sup> edition) Wiley, New York.

- 16) L.W.Nester, C.N. Roberts and M.L.Nester 1995, Microbiology – A Human Perspectives, Iowa, USA.
- 17) R.Y.Stainer, J.I.Ingraham, M.L. Wheelis and P.R.Painter 1999 General Microbiological, McMillan Educational Ltd. London.
- 18) Principles of Biochemistry. Lehninger, AL. 1993 2<sup>nd</sup> edition, CSB Publishers.
- 19) Outlines of Biochemistry, 5/e - Conn. E.E., Stumpf, P.K. Bruening, G and Doi. R.H. John Wiley & Sons (1987)
- 20) Biochemistry, Voet. D and Voet. JG. 1990. John Wiley & Sons. NY.
- 21) Text book of Biochemistry. 2/e. Devlin. T.M. 1986. Wiley Medical Publications, NY.
- 22) Biochemistry, 2/e, Stryer. L. 1998, W.H. Freeman and Company, NY.
- 23) Biochemistry, 2/e. Zubay. G. 1998. McMillan Publishers NY. Collier McMillan Company Publishers, London.
- 24) Enzymes. Ribozymes and DNAzymes, P. Palanivelu, 2007, Twenty first Century Publications, Palkalai Nagar, Madurai - 625 021.
- 25) Laboratory manual in biochemistry, 5/e, J. Jayaraman, New Age international publishers, 1996.
- 26) Principles of practical biochemistry, K. Wilson and J. Walker, Cambridge University press, 2000.
- 27) An Introduction to practical biochemistry, D.T. Plummer. TATA McGraw Hill, 1997.
- 28) Microbial Physiology, 4/e, Moat AG, Foster JW and Spector MP. Wiley-Liss. 2002.
- 29) Gene VII. Benjamin Lewin, 2000: Oxford University Press.
- 30) Molecular biology of the Gene, 4/e. Watson, Hopkins, Roserts. Steits and Weiner, 1987, The Benjamin/Cumming Publishing Company, Inc.
- 31) Molecular Genetics of Bacteria, 2/e, Larry Snyder and Wendy Champness, 2003, ASM press. Washington DC.
- 32) Microbial genetics. David Friefelder, 1987, Narosa Publishing Mouse.
- 33) Essential of immunology, Roitt. I.M. 1998, ELBS, Blackwell scientific publication.
- 34) Immunology, 3/e. Kuby, J. 1997, W.H. Freeman and company. NY.
- 35) Crueger, W. and A. Crueger (2000), Biotechnology, A Text book of Industrial Microbiology. Panima Publishers, New Delhi.
- 36) Flinger, M.C., and Drew, S.W., (1999), Encyclopedia of Bioprocess technology - Fermentation, Biocatalysis and Bioseparation (Volumes I - V), John Wiley and Sons, New York.
- 37) Sambrook, J. Cold Spring Harbor laboratory (2002).
- 38) Advanced bacterial genetics, David, RW, Botstein, D & Roth, JR. Cold Spring Harbor laboratory (1980).

- 39) Data basis in life sciences and Biotechnology: A directory - DBT, Govt. of India, March 1995.
- 40) Protein Structure Analysis - Springer Lab Manual. R.M.Kamp, T.Choli- Papadaopoulou B. Witman Liebold.
- 41) Computer in microbiology- a practical approach. T.N, Bryant, JWT Wimpenny, IRL, Press, 1989.
- 42) Jawetz. E. Melnic. JL. & Adelberg. EA. Medical microbiology 22/e McGraw Hill Companies, 2004.
- 43) Rangasami G and Bagyaraj DJ. 1993. Agricultural Microbiology 2/e Prentice- Hall publications
- 44) Rangasami G and Bagyaraj DJ. 1993. Agricultural Microbiology 2/e Prentice- Hall publications.
- 45) Ronald Atlas, Bartha Richard, 1987. Microbial ecology 2/e Benjamin/ Cummings publications.
- 46) Enzymes, Ribozymes and DNAzymes, P. Palanivelu, Twentyfirst Century Publications. P
- 47) Enzymes-Biochemistry, Biotechnology, Clinical chemistry- T. Palmer -East-Westpress. New Delhi (2.004)

#### SCHEME OF EXAMINATIONS

| Subject code | Title of the Paper                        | Weekly contact hours | No. of credits | Examination Hours | Marks |      |            |
|--------------|-------------------------------------------|----------------------|----------------|-------------------|-------|------|------------|
|              |                                           |                      |                |                   | Int.  | Ext. | Total      |
|              | <b>I Semester</b>                         |                      |                |                   |       |      |            |
|              | General Micro Biology                     | 6                    | 6              | 3                 | 25    | 75   | 100        |
|              | Cell Biology & Biochemistry               | 6                    | 6              | 3                 | 25    | 75   | 100        |
|              | Agricultural & Environmental Microbiology | 6                    | 6              | 3                 | 25    | 75   | 100        |
|              | Practical – I                             | 6                    | 3              | 6                 | 40    | 60   | 100        |
|              | Medical Microbiology (T&P)                | 6                    | 4              | 3                 | 25    | 75   | 100        |
|              | <b>Total</b>                              | <b>30</b>            | <b>25</b>      |                   |       |      | <b>500</b> |

|  |                                        |           |           |   |    |    |             |
|--|----------------------------------------|-----------|-----------|---|----|----|-------------|
|  | <b>II Semester</b>                     |           |           |   |    |    |             |
|  | Immunology                             | 6         | 6         | 3 | 25 | 75 | 100         |
|  | Molecular biology & Microbial Genetics | 6         | 6         | 3 | 25 | 75 | 100         |
|  | Fermentation Technology                | 6         | 6         | 3 | 25 | 75 | 100         |
|  | Practical – II                         | 6         | 3         | 6 | 40 | 60 | 100         |
|  | Applied Microbiology                   | 6         | 4         | 3 | 25 | 75 | 100         |
|  | <b>Total</b>                           | <b>30</b> | <b>25</b> |   |    |    | <b>500</b>  |
|  | <b>III Semester</b>                    |           |           |   |    |    |             |
|  | Genomics & Proteomics (T&P)            | 6         | 4         | 3 | 25 | 75 | 100         |
|  | Microbial Bioremediation               | 6         | 6         | 3 | 25 | 75 | 100         |
|  | Genetic Engineering                    | 6         | 6         | 3 | 25 | 75 | 100         |
|  | Bioinformatics                         | 6         | 6         | 3 | 25 | 75 | 100         |
|  | Practical – III                        | 6         | 3         | 6 | 25 | 75 | 100         |
|  | <b>Total</b>                           | <b>30</b> | <b>25</b> |   |    |    | <b>500</b>  |
|  | <b>IV Semester</b>                     |           |           |   |    |    |             |
|  | Research Methodology                   | 5         | 5         | 3 | 25 | 75 | 100         |
|  | Project and Viva – voce                | 25        | 10        |   | 20 | 80 | 100         |
|  | <b>Total</b>                           | <b>30</b> | <b>15</b> |   |    |    | <b>200</b>  |
|  | <b>Grand Total</b>                     |           | <b>90</b> |   |    |    | <b>1700</b> |

|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Programme:</b>          | <b>M.Sc. MICROBIOLOGY</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Programme code:</b>     | <b>22PGMB</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Duration:</b>           | <b>2 Years [PG]</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Programme Outcomes:</b> | <p><b>PO1: Disciplinary Knowledge</b></p> <p>Capable of demonstrating detailed knowledge and expertise in all the disciplines of the subject.</p> <p><b>PO2: Communication Skills</b></p> <p>Able to express thoughts, ideas, concepts, scientific information, experiments and its significance effectively in writing and verbal, communicate with confidence to different groups, using appropriate media.</p> <p><b>PO3: Moral and Ethical Awareness</b></p> <p>Ability to employ values in conducting one's life, use ethical practice at work, avoiding fabrication, misinterpretation and plagiarism, adhering to intellectual property rights and appreciate ethical solutions for environmental sustainability.</p> <p><b>PO4: Analytical Reasoning</b></p> <p>Ability to evaluate the reliability and relevance of evidence, identify flaws, analyze and synthesize data from different sources.</p> <p><b>PO5: Contribution to Society</b></p> <p>Solve public issues concerned with public health and safety for the welfare of the society.</p> <p><b>PO6: Scientific Reasoning</b></p> <p>Ability to identify, analyze, interpret and draw conclusions from qualitative and quantitative data, critically evaluate ideas, evidences and experiences,</p> |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p>with an open mind and reasoned perspective.</p> <p><b>PO7 : Employability Skill</b></p> <p>Equip with skills, based on current trends and future expectations for career development and placements.</p> <p><b>PO8: Entrepreneurial Skill</b></p> <p>To create efficient entrepreneurs by accelerating critical thinking, problem solving, decision making and leadership qualities to facilitate startups.</p> <p><b>PO9: Research Related Skill</b></p> <p>A sense of inquiry and capability for questioning, problem arising, synthesizing and articulating. Ability to recognize cause and effect relationships, define problems, formulate and test hypothesis, analyze, interpret and draw conclusions from data, establish hypothesis, predict cause and effect relationships, ability to plan, execute and report the results of an experiment or investigation.</p> <p><b>PO10: Lifelong Learning</b></p> <p>Identify the need for skills necessary to be successful in future, through self- paced and self - directed learning aiming at personal development, meeting economic, social and cultural objectives, adapting to changing trends and demands of work place.</p> <p><b>PO11: Instrumentation Skill</b></p> <p>Able to handle conventional and sophisticated instruments thereby acquiring employability skills.</p> <p><b>PO12: Leadership Readiness and Qualities</b></p> <p>Capability for building a team, identifying the tasks, setting direction, formulating an inspiring vision, employing skills to reach the right destination, smoothly.</p> |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                    | <p><b>PO13: Information/ Digital Literacy</b></p> <p>Ability to use software for interpretation and analysis of data in a variety of learning situations.</p> <p><b>PO14: Cooperation and Team Work</b></p> <p>Ability to work effectively with diverse teams, facilitate cooperative or coordinated effort on the part of a group and act together as a group or as a team in the interest of a common cause and work efficiently as a member of a team.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Programme Specific Outcomes</b> | <p><b>PSO-1: Placement</b></p> <p>Prepare the students in varied disciplines like agriculture, industry - medical, pharma, dairy, hotel, food and food processing, immunological, cosmetics, vermitechnology and water treatment for effective and respectful placement.</p> <p><b>PSO-2: Entrepreneurship</b></p> <p>To create effective entrepreneur by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.</p> <p><b>PSO-3: Research and Development</b></p> <p>Design and implement HR systems that comply with good laboratory practices, following ethical values, leading the organization towards growth and development. .</p> <p><b>PSO-4: Contribution to Society</b></p> <p>To contribute to the development of society and produce microbiological products, by collaborating with stake holders, related to the betterment of environment and mankind at the national and global level.</p> |

### Template for P.G., Programmes

| Semester-I                        | Credit    | Hours     | Semester-II                          | Credit    | Hours     | Semester-III                        | Credit    | Hours     | Semester-IV                                                                   | Credit    | Hours     |
|-----------------------------------|-----------|-----------|--------------------------------------|-----------|-----------|-------------------------------------|-----------|-----------|-------------------------------------------------------------------------------|-----------|-----------|
| Core-I                            | 5         | 7         | Core-IV                              | 5         | 6         | Core-VII                            | 5         | 6         | Core-XI                                                                       | 5         | 6         |
| Core-II                           | 5         | 7         | Core-V                               | 5         | 6         | Core-VIII                           | 5         | 6         | Core-XII                                                                      | 5         | 6         |
| Core – III                        | 4         | 6         | Core – VI                            | 4         | 6         | Core – IX                           | 5         | 6         | Project with viva voce                                                        | 7         | 10        |
| Elective -I<br>Discipline Centric | 3         | 5         | Elective – III<br>Discipline Centric | 3         | 4         | Core – X                            | 4         | 6         | Elective - VI<br>(Industry / Entrepreneurship)<br>20% Theory<br>80% Practical | 3         | 4         |
| Elective-II<br>Generic:           | 3         | 5         | Elective -IV<br>Generic:             | 3         | 4         | Elective - V<br>Discipline Centric  | 3         | 3         | Skill Enhancement course / Professional Competency Skill                      | 2         | 4         |
|                                   |           |           | Skill Enhancement I                  | 2         | 4         | 3.6 Skill Enhancement II            | 2         | 3         | Extension Activity                                                            | 1         |           |
|                                   |           |           |                                      |           |           | 3.7 Internship/ Industrial Activity | 2         | -         |                                                                               |           |           |
|                                   | <b>20</b> | <b>30</b> |                                      | <b>22</b> | <b>30</b> |                                     | <b>26</b> | <b>30</b> |                                                                               | <b>23</b> | <b>30</b> |
| <b>Total Credit Points -91</b>    |           |           |                                      |           |           |                                     |           |           |                                                                               |           |           |



**Based Credits and Hours Distribution System  
for all Post – Graduate Courses including Lab Hours**

**First Year – Semester – I**

| <b>Part</b> | <b>List of Courses</b> | <b>Credits</b> | <b>No. of Hours</b> |
|-------------|------------------------|----------------|---------------------|
|             | Core – I               | 5              | 7                   |
|             | Core – II              | 5              | 7                   |
|             | Core – III             | 4              | 6                   |
|             | Elective – I           | 3              | 5                   |
|             | Elective – II          | 3              | 5                   |
|             |                        | <b>20</b>      | <b>30</b>           |

**Semester-II**

| <b>Part</b> | <b>List of Courses</b>             | <b>Credits</b> | <b>No. of Hours</b> |
|-------------|------------------------------------|----------------|---------------------|
|             | Core – IV                          | 5              | 6                   |
|             | Core – V                           | 5              | 6                   |
|             | Core – VI                          | 4              | 6                   |
|             | Elective – III                     | 3              | 4                   |
|             | Elective – IV                      | 3              | 4                   |
|             | Skill Enhancement Course [SEC] - I | 2              | 4                   |
|             |                                    | <b>22</b>      | <b>30</b>           |

**Second Year – Semester – III**

| <b>Part</b> | <b>List of Courses</b>                     | <b>Credits</b> | <b>No. of Hours</b> |
|-------------|--------------------------------------------|----------------|---------------------|
|             | Core – VII                                 | 5              | 6                   |
|             | Core – VIII                                | 5              | 6                   |
|             | Core – IX                                  | 5              | 6                   |
|             | Core (Industry Module) – X                 | 4              | 6                   |
|             | Elective – V                               | 3              | 3                   |
|             | Skill Enhancement Course - II              | 2              | 3                   |
|             | Internship / Industrial Activity [Credits] | 2              | -                   |
|             |                                            | <b>26</b>      | <b>30</b>           |

**Semester-IV**

| <b>Part</b> | <b>List of Courses</b>                                         | <b>Credits</b> | <b>No. of Hours</b> |
|-------------|----------------------------------------------------------------|----------------|---------------------|
|             | Core – XI                                                      | 5              | 6                   |
|             | Core – XII                                                     | 5              | 6                   |
|             | Project with VIVA VOCE                                         | 7              | 10                  |
|             | Elective – VI (Industry Entrepreneurship)                      | 3              | 4                   |
|             | Skill Enhancement Course – III / Professional Competency Skill | 2              | 4                   |
|             | Extension Activity                                             | 1              | -                   |
|             |                                                                | <b>23</b>      | <b>30</b>           |

**Total 91 Credits for PG Courses**

| <b>METHODS OF EVALUATION</b> |                                                                                                                                                                                                                                                                                                                                                                                |                  |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| <b>Internal Evaluation</b>   | Continuous Internal Assessment Test                                                                                                                                                                                                                                                                                                                                            | <b>25 Marks</b>  |
|                              | Assignments / Snap Test / Quiz                                                                                                                                                                                                                                                                                                                                                 |                  |
|                              | Seminars                                                                                                                                                                                                                                                                                                                                                                       |                  |
|                              | Attendance and Class Participation                                                                                                                                                                                                                                                                                                                                             |                  |
| <b>External Evaluation</b>   | End Semester Examination                                                                                                                                                                                                                                                                                                                                                       | <b>75 Marks</b>  |
| <b>Total</b>                 |                                                                                                                                                                                                                                                                                                                                                                                | <b>100 Marks</b> |
| <b>METHODS OF ASSESSMENT</b> |                                                                                                                                                                                                                                                                                                                                                                                |                  |
| <b>Remembering (K1)</b>      | <ul style="list-style-type: none"> <li>The lowest level of questions require students to recall information from the course content</li> <li>Knowledge questions usually require students to identify information in the textbook.</li> </ul>                                                                                                                                  |                  |
| <b>Understanding (K2)</b>    | <ul style="list-style-type: none"> <li>Understanding of facts and ideas by comprehending, organizing, comparing, translating, interpolating and interpreting in their own words.</li> <li>The questions go beyond simple recall and require students to combine data together</li> </ul>                                                                                       |                  |
| <b>Application (K3)</b>      | <ul style="list-style-type: none"> <li>Students have to solve problems by using/applying a concept learned in the classroom.</li> <li>Students must use their knowledge to determine an exact response.</li> </ul>                                                                                                                                                             |                  |
| <b>Analyze (K4)</b>          | <ul style="list-style-type: none"> <li>Analyzing the question is one that asks the student to break down something into its component parts.</li> <li>Analyzing requires students to identify reasons, causes or motives and reach conclusions or generalizations.</li> </ul>                                                                                                  |                  |
| <b>Evaluate (K5)</b>         | <ul style="list-style-type: none"> <li>Evaluation requires an individual to make judgment on something.</li> <li>Questions to be asked to judge the value of an idea, a character, a work of art, or a solution to a problem.</li> <li>Students are engaged in decision-making and problem-solving.</li> <li>Evaluation questions do not have single right answers.</li> </ul> |                  |
| <b>Create (K6)</b>           | <ul style="list-style-type: none"> <li>The questions of this category challenge students to get engaged in creative and original thinking.</li> <li>Developing original ideas and problem-solving skills</li> </ul>                                                                                                                                                            |                  |

**Credit Distribution for PG Courses**  
**First Year**  
**Semester-I**

| <b>Course</b>                     | <b>Course Title</b>                                                                                                                                                                        | <b>Credit</b> | <b>No. of Hours</b> |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------------|
| Core-I                            | General Microbiology and Microbial Diversity                                                                                                                                               | 5             | 7                   |
| Core-II                           | Microbial Physiology                                                                                                                                                                       | 5             | 7                   |
| Core – III                        | Practical I – General Microbiology, Microbial Diversity and Microbial Physiology                                                                                                           | 4             | 6                   |
| Elective -I<br>Discipline Centric | Forensic Science/<br>Nanobiotechnology/<br>Microalgal Technology<br>(Among the three choices anyone can be chosen by the student)                                                          | 3             | 5                   |
| Elective-II<br>Generic:           | Bioinstrumentation/<br>Herbal Technology and Cosmetic Microbiology /<br>Essentials of Laboratory Management and Biosafety<br>(Among the three choices anyone can be chosen by the student) | 3             | 5                   |
|                                   | Entrepreneurship in Biobusiness                                                                                                                                                            |               |                     |
| <b>Total</b>                      |                                                                                                                                                                                            | <b>20</b>     | <b>30</b>           |

**First Year: Semester-II**

| <b>Course</b>                        | <b>Course Title</b>                                                                                                                                         | <b>Credit</b> | <b>No. of Hours</b> |
|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------------|
| Core-IV                              | Medical Bacteriology and Mycology                                                                                                                           | 5             | 6                   |
| Core-V                               | Medical Virology and Parasitology                                                                                                                           | 5             | 6                   |
| Core – VI\                           | Practical II - Medical Microbiology                                                                                                                         | 4             | 6                   |
| Elective – III<br>Discipline Centric | Epidemiology/<br>Clinical Diagnostic Microbiology/<br>Bioremediation<br>(Among the three choices anyone can be chosen by the student)                       | 3             | 4                   |
| Elective -IV<br>Generic:             | Bioinformatics/<br>Biosafety, Bioethics and IPR /<br>Clinical Research and Clinical Trials<br>(Among the three choices anyone can be chosen by the student) | 3             | 4                   |
| Skill Enhancement I                  | Vermitechnology                                                                                                                                             | 2             | 4                   |
| <b>Total</b>                         |                                                                                                                                                             | <b>22</b>     | <b>30</b>           |

**Second Year: Semester-III**

| <b>Course</b>                          | <b>Course Title</b>                                                                                                                                                          | <b>Credit</b> | <b>No. of Hours</b> |
|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------------|
| Core-VII                               | Immunology and Microbial Genetics                                                                                                                                            | 5             | 6                   |
| Core-VIII                              | Molecular Biology and Recombinant DNA Technology                                                                                                                             | 5             | 6                   |
| Core – IX                              | Practical III - Immunology, Microbial Genetics and Molecular Biology                                                                                                         | 5             | 6                   |
| Core – X                               | Soil Microbiology and Microbial Ecology/<br>Microbial Toxicology/<br>Water Conservation and Water Treatment<br>(Among the three choices anyone can be chosen by the student) | 4             | 6                   |
| Elective – V<br>Discipline Centric     | Fermentation Technology and<br>Pharmaceutical Microbiology                                                                                                                   | 3             | 3                   |
| 3.6 Skill<br>Enhancement II            | Organic Farming and Biofertiliser<br>Technology                                                                                                                              | 2             | 3                   |
| 3.7 Internship/<br>Industrial Activity | Internship / Industrial Activity                                                                                                                                             | 2             | -                   |
|                                        | Total                                                                                                                                                                        | <b>26</b>     | <b>30</b>           |

**Second Year: Semester-IV**

| <b>Course</b>                                                                    | <b>Course Title</b>                                                                                                                                 | <b>Credit</b> | <b>No. of Hours</b> |
|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------------|
| Core-XI                                                                          | Food and Environmental Microbiology                                                                                                                 | 5             | 6                   |
| Core-XII                                                                         | Practical IV - Applied Microbiology                                                                                                                 | 5             | 6                   |
| Project                                                                          | Project with Viva Voce                                                                                                                              | 7             | 10                  |
| Elective - VI<br>(Industry /<br>Entrepreneurship)<br>20% Theory<br>80% Practical | Bioenergy/<br>Marine Microbiology/<br>Life Science for Competitive<br>Examinations<br>(Among the three choices anyone can be chosen by the student) | 3             | 4                   |
| Skill Enhancement<br>course / Professional<br>Competency Skill                   | Research Methodology and Biostatistics                                                                                                              | 2             | 4                   |
| Extension Activity                                                               | Microbial Quality Control and Testing                                                                                                               | 1             |                     |
|                                                                                  |                                                                                                                                                     | <b>23</b>     | <b>30</b>           |

### Credit Distribution for PG Course

| S.No      | Course Details                                         | Credit    |
|-----------|--------------------------------------------------------|-----------|
| <b>1</b>  | Core Course [12 Courses X 4 Credits]                   | 48        |
| <b>2</b>  | Elective Course [ 6 Courses X 3 Credits]               | 18        |
| <b>3</b>  | Skill Enhancement Course [3 Courses X 2 Credits]       | 6         |
| <b>4A</b> | Professional Competency Course & Industry Module       | 4         |
| <b>4B</b> | Project Work VIVA VOCE                                 | 4         |
| <b>5</b>  | Ability Enhancement Compulsory Course [ 4 Courses X 2] | 8         |
| <b>6</b>  | Internship                                             | 2         |
| <b>7</b>  | Extension Activity                                     | 1         |
|           |                                                        | <b>91</b> |

**FIRST YEAR**

**FIRST SEMESTER**

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                                                                                                            | Category      | L | T | P | S | Credits | Inst. Hours | Marks        |                   |       |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---|---|---|---|---------|-------------|--------------|-------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                         |               |   |   |   |   |         |             | CIA          | External          | Total |
| 22MBP GCT1               | General Microbiology and Microbial Diversity                                                                                                                                                                                                                                                                                                                                                                                                            | Core Course I | Y | Y | - | - | 4       | 6           | 25           | 75                | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                         |               |   |   |   |   |         |             |              |                   |       |
| CO1                      | Acquire knowledge on the principles of different types of microscopes and their applications.                                                                                                                                                                                                                                                                                                                                                           |               |   |   |   |   |         |             |              |                   |       |
| CO2                      | Explain various pure culture techniques and discuss sterilization methods.                                                                                                                                                                                                                                                                                                                                                                              |               |   |   |   |   |         |             |              |                   |       |
| CO3                      | Exemplify, isolate and cultivate microalgae from diverse environmental sources.                                                                                                                                                                                                                                                                                                                                                                         |               |   |   |   |   |         |             |              |                   |       |
| CO4                      | Compare and contrast the structure of bacteria and fungi. Illustrate nutritional requirements and growth in bacteria.                                                                                                                                                                                                                                                                                                                                   |               |   |   |   |   |         |             |              |                   |       |
| CO5                      | Discuss the importance and conservation of microbial diversity.                                                                                                                                                                                                                                                                                                                                                                                         |               |   |   |   |   |         |             |              |                   |       |
| UNIT                     | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                 |               |   |   |   |   |         |             | No. of Hours | Course Objectives |       |
| I                        | History and Scope of Microbiology. Microscopy – Principles and applications. Types of Microscopes - Bright field, Dark-field, Phase-contrast, Fluorescence microscope, Transmission electron microscope (TEM) and Scanning electron microscope (SEM). Sample preparation for SEM & TEM. Atomic force, Confocal microscope. Micrometry – Stage, Ocular and its applications.                                                                             |               |   |   |   |   |         |             | 20           | CO1               |       |
| II                       | Microbial techniques - Safety guidelines in Microbiology Laboratories. Sterilization, Disinfection and its validation. Staining methods – Simple, Differential and Special staining. Automated Microbial identification systems - Pure cultures techniques – Cultivation of Anaerobic organisms. Maintenance and preservation of pure cultures. Culture collection centres - National and International.                                                |               |   |   |   |   |         |             | 15           | CO4               |       |
| III                      | Algae - Distribution, morphology, classification, reproduction and economic importance. Isolation of algae from soil and water. Media and methods used for culturing algae, Strain selection and large-scale cultivation. Life cycle - <i>Chlamydomonas</i> , <i>Volvox</i> <i>Spirogyra</i> (Green algae), <i>Nostoc</i> (Cyanobacteria) <i>Ectocarpus</i> , <i>Sargassum</i> (Brown algae), <i>Polysiphonia</i> , <i>Batrachospermum</i> (Red algae). |               |   |   |   |   |         |             | 15           | CO3               |       |
| IV                       | Bacterial Structure, properties and biosynthesis of cellular                                                                                                                                                                                                                                                                                                                                                                                            |               |   |   |   |   |         |             | 20           | CO2               |       |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    |     |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----|
|                  | components – Cell wall. Actinomycetes and Fungi - Distribution, morphology, classification, reproduction and economic importance. Sporulation. Growth and nutrition - Nutritional requirements, Growth curve, Kinetics of growth, Batch culture, Synchronous growth, Measurement of growth and factors affecting growth.                                                                                                                                                                                                                             |                    |     |
| V                | Biodiversity - Introduction to microbial biodiversity – Thermophiles - Classification, Thermophilic Archaeobacteria and its applications. Methanogens - Classification, Habitats, applications. Alkaliphiles and Acidophiles - Classification, discovery basin, its cell wall and membrane. Barophiles - Classification and its applications. Halophiles - Classification, discovery basin, cell walls and membranes – purple membrane, compatible solutes. Microbial stress response - Osmoadaptation / halotolerance - Applications of halophiles. | 20                 | CO5 |
|                  | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 90                 |     |
| Course Outcomes  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                    |     |
| CO1              | Examine various microbes employing the microscopic techniques learnt. Measure and compare the size of microbes.                                                                                                                                                                                                                                                                                                                                                                                                                                      | PO1, PO4, PO11     |     |
| CO2              | Create aseptic conditions by following good laboratory practices.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | PO1, PO4           |     |
| CO3              | Identify and cultivate the algae understanding their habitat. Analyze the morphology, classify and propagate depending on its economic importance.                                                                                                                                                                                                                                                                                                                                                                                                   | PO7, PO8, PO9      |     |
| CO4              | Differentiate and appreciate the anatomy of various microbes. Plan the growth of microbes for different environmental conditions.                                                                                                                                                                                                                                                                                                                                                                                                                    | PO3, PO4,PO7       |     |
| CO5              | Categorize and cultivate a variety of extremophiles following standard protocols for industrial applications.                                                                                                                                                                                                                                                                                                                                                                                                                                        | PO5, PO7, PO8, PO9 |     |
| Text Books       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    |     |
| 1.               | Kanunga R. (2017). Ananthanarayanan and Panicker’s Text book of Microbiology. (10 <sup>th</sup> Edition). Universities Press (India ) Pvt. Ltd.                                                                                                                                                                                                                                                                                                                                                                                                      |                    |     |
| 2.               | Chan E.C.S., Pelczar M. J. Jr. and Krieg N. R. (2010). Microbiology. (5 <sup>th</sup> Edition). Mc.Graw Hill. Inc, New York.                                                                                                                                                                                                                                                                                                                                                                                                                         |                    |     |
| 3.               | Prescott L. M., Harley J. P. and Klein D. A. (2004). Microbiology. (6 <sup>th</sup> Edition). McGraw - Hill company, New York.                                                                                                                                                                                                                                                                                                                                                                                                                       |                    |     |
| 4.               | White D. Drummond J. and Fuqua C. (2011). The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford, New York.                                                                                                                                                                                                                                                                                                                                                                                                                 |                    |     |
| 5.               | Dubey R.C. and Maheshwari D. K. (2009). Textbook of Microbiology. S. Chand, Limited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                    |     |
| REFERENCES BOOKS |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    |     |
| 1.               | Tortora G. J., Funke B. R. and Case C. L. (2015). Microbiology: An Introduction (12 <sup>th</sup> Edition).Pearson, London, United Kingdom                                                                                                                                                                                                                                                                                                                                                                                                           |                    |     |

|                              |                                                                                                                                                                                         |           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 2.                           | Webster J. and Weber R.W.S. (2007). Introduction to Fungi. (3 <sup>rd</sup> Edition). Cambridge University Press, Cambridge.                                                            |           |
| 3.                           | Schaechter M. and Leaderberg J. (2004). The Desk encyclopedia of Microbiology. Elseiver Academic Press, California.                                                                     |           |
| 4.                           | Ingraham, J.L. and Ingraham, C.A. (2000) Introduction to Microbiology. (2 <sup>nd</sup> Edition). Books / Cole Thomson Learning, UK.                                                    |           |
| 5.                           | Madigan M. T., Bender K.S., Buckley D. H. Sattley W. M. and Stahl (2018) Brock Biology of Microorganisms. (15 <sup>th</sup> Edition). Pearson.                                          |           |
| Web Resources                |                                                                                                                                                                                         |           |
| 1.                           | <a href="http://sciencenetlinks.com/tools/microbeworld">http://sciencenetlinks.com/tools/microbeworld</a>                                                                               |           |
| 2.                           | <a href="https://www.microbes.info/">https://www.microbes.info/</a>                                                                                                                     |           |
| 3.                           | <a href="https://www.asmscience.org/VisualLibrary">https://www.asmscience.org/VisualLibrary</a>                                                                                         |           |
| 4.                           | <a href="https://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=404">https://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=404</a>                                               |           |
| 5.                           | <a href="https://www.grsmu.by/files/file/university/cafedry//files/essential_microbiology.pdf">https://www.grsmu.by/files/file/university/cafedry//files/essential_microbiology.pdf</a> |           |
| Methods of Evaluation        |                                                                                                                                                                                         |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                                    | 25 Marks  |
|                              | Assignments                                                                                                                                                                             |           |
|                              | Seminars                                                                                                                                                                                |           |
|                              | Attendance and Class Participation                                                                                                                                                      |           |
| External Evaluation          | End Semester Examination                                                                                                                                                                | 75 Marks  |
|                              | Total                                                                                                                                                                                   | 100 Marks |
| Methods of Assessment        |                                                                                                                                                                                         |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                                              |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                                          |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                                                  |           |
| Analyze (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                                                         |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                                                                                  |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                                                                                |           |



### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | M    |      |      | M    |      |      |      |      |      |       | S     |       |       |       |
| CO2 | L    |      |      | S    |      |      |      |      |      |       |       |       |       |       |
| CO3 |      |      |      |      |      |      | S    | S    | M    |       |       |       |       |       |
| CO4 |      |      | S    | S    |      |      | S    |      |      |       |       |       |       |       |
| CO5 |      |      |      |      | S    |      | S    | S    | S    |       |       |       |       |       |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                       | Category       | L | T | P | S | Credits | Inst. Hours | Marks |                     |                          |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---|---|---|---|---------|-------------|-------|---------------------|--------------------------|
|                          |                                                                                                                                                                                                                                                                    |                |   |   |   |   |         |             | CIA   | External            | Total                    |
| 22MBPGC T2               | Microbial Physiology                                                                                                                                                                                                                                               | Core Course II | Y | Y | - | - | 4       | 6           | 25    | 75                  | 100                      |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                    |                |   |   |   |   |         |             |       |                     |                          |
| CO1                      | Illustrate Bacterial nutrition and their utilization.                                                                                                                                                                                                              |                |   |   |   |   |         |             |       |                     |                          |
| CO2                      | Discuss cultivation methods and factors related to microbial growth.                                                                                                                                                                                               |                |   |   |   |   |         |             |       |                     |                          |
| CO3                      | Demonstrate concepts of microbial metabolism.                                                                                                                                                                                                                      |                |   |   |   |   |         |             |       |                     |                          |
| CO4                      | Impart the fundamentals and importance of biosynthetic pathways.                                                                                                                                                                                                   |                |   |   |   |   |         |             |       |                     |                          |
| CO5                      | Discuss the methods involved in Photosynthesis.                                                                                                                                                                                                                    |                |   |   |   |   |         |             |       |                     |                          |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                     |                |   |   |   |   |         |             |       | <b>No. of Hours</b> | <b>Course Objectives</b> |
| I                        | Nutrition – Nutritional requirements and types in bacteria – Phototrophs, Chemotrophs, Autotrophs and Heterotrophs. Nutrient transport mechanisms- Passive diffusion, Facilitated diffusion, Active transport, Group translocation and Specific transport system.. |                |   |   |   |   |         |             |       | 20                  | CO1                      |
| II                       | Microbial growth – Growth curve and Measurement of Growth – Cell Number and Cell Mass and metabolic activity. Batch, Continuous, Synchronous and Asynchronous cultures, Factors affecting growth.                                                                  |                |   |   |   |   |         |             |       | 20                  | CO2                      |
| III                      | Enzymes – properties, functions and regulation. Basic concepts of metabolism, Oxidation –                                                                                                                                                                          |                |   |   |   |   |         |             |       | 25                  | CO3                      |

|                 |                                                                                                                                                                                                                                                                                                                                       |                               |     |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----|
|                 | reduction reactions, Energy generation by anaerobic metabolism – Glycolysis, Pentose Phosphate pathway, ED pathway, Fermentation. Energy generation by Aerobic metabolism - TCA cycle, Glycoxylate pathway and Electron Transport chain, Mechanism of ATP synthesis – Chemiosmosis, Pasteur effect. Metabolism of lipids-β oxidation. |                               |     |
| IV              | Anaerobic Respiration. Nitrogen, Sulphur, Iron and Hydrogen Oxidation. Methanogenesis. Biosynthesis – Gluconeogenesis, Peptidoglycan synthesis, Amino acids, Purines, Pyrimidines Fattyacids, Triglycerides, Phospholipids and Sterols.                                                                                               | 13                            | CO4 |
| V               | Photosynthesis – process, antenna of light-harvesting pigments, Photochemical reaction centers, Photosynthetic Electron Transport Chain-Cyclic and Non-cyclic. Oxygenic and Anoxygenic Photosynthesis. Calvin-Benson cycle. Bioluminescence - Process and application.                                                                | 12                            | CO5 |
|                 | Total                                                                                                                                                                                                                                                                                                                                 | 60                            |     |
| Course Outcomes |                                                                                                                                                                                                                                                                                                                                       |                               |     |
| Course Outcomes | On completion of this course, students will;                                                                                                                                                                                                                                                                                          |                               |     |
| CO1             | Apply knowledge about nutritional requirement, modes of nutrient transport in microorganisms to various disciplines of Microbiology.                                                                                                                                                                                                  | PO1, PO4, PO6, PO7, PO9       |     |
| CO2             | Analyse microbial growth, factors influencing growth and its measurement techniques for applications in various industries.                                                                                                                                                                                                           | PO1, PO4, PO5,PO6, PO9        |     |
| CO3             | Compare various metabolic pathways and discuss the properties and functions of enzymes.                                                                                                                                                                                                                                               | PO4, PO6, PO7, PO8, PO9, PO10 |     |
| CO4             | Apply anaerobic respiration and biosynthetic pathways to enhance/control microbial growth.                                                                                                                                                                                                                                            | PO4,PO5, PO6, PO7, PO9, PO10  |     |
| CO5             | Assimilate methods involved in microbial photosynthesis and bioluminescence.                                                                                                                                                                                                                                                          | PO4,PO5, PO6, PO7, PO9, PO10  |     |
| Text Books      |                                                                                                                                                                                                                                                                                                                                       |                               |     |
| 1.              | Stanier R.Y., Ingraham, J.L., Wheelis, M.L and Painter, P.R. (2010). General Microbiology. 5th Edn. Macmilan education Ltd. London.                                                                                                                                                                                                   |                               |     |

|                              |                                                                                                                                                                                           |           |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 2.                           | Prescott. L.M., Harley. J.P., Klein. D.A. (1993). Microbiology. 2 <sup>nd</sup> edn. Wm. C. Brown publishers, Dubuque.                                                                    |           |
| 3.                           | Moat, A.G. and Foster, J.W. (2003). Microbial Physiology.4th Edn. John Wiley and Sons, New York.                                                                                          |           |
| 4.                           | Doelle, H.W. (1975) Bacterial Metabolism, 2 <sup>nd</sup> Edn. Academic Press, London.                                                                                                    |           |
| 5.                           | Caldwell, D.R (2000) Microbial physiology and metabolism, 2 <sup>nd</sup> Edn. Star publishing, Belmont, California.                                                                      |           |
| <b>References Books</b>      |                                                                                                                                                                                           |           |
| 1.                           | Salle. A.J. (1992). Fundamental Principles of Bacteriology. 7 <sup>th</sup> edn. McGraw Hill Inc.New York.                                                                                |           |
| 2.                           | Madigan, M.T., Martinko, J.M., & ParkerJ. (2000). Brock Biology of Microorganisms. 9 <sup>th</sup> Edn. Prentice Hall International, Inc, London.                                         |           |
| 3.                           | Ingraham, J.L., & Ingraham, C.A. (2000). Introduction to Microbiology. 2 <sup>nd</sup> Edn. Brook /Cole. Singapore.                                                                       |           |
| 4.                           | Gottschalk, G. (1986). Bacterial Metabolism.2 <sup>nd</sup> Edn. Springer-Verlag, New York.                                                                                               |           |
| 5.                           | Rose, A.H. (1976). An Introduction to Microbial Physiology. 3 <sup>rd</sup> Edn. Plenum, New York.                                                                                        |           |
| <b>Web Resources</b>         |                                                                                                                                                                                           |           |
| 1.                           | <a href="https://courses.lumenlearning.com/boundless-microbiology/chapter/microbial-nutrition/">https://courses.lumenlearning.com/boundless-microbiology/chapter/microbial-nutrition/</a> |           |
| 2.                           | <a href="https://www.lamission.edu/lifesciences/lecturenote/mic20/Chap06Growth.pdf">https://www.lamission.edu/lifesciences/lecturenote/mic20/Chap06Growth.pdf</a>                         |           |
| 3.                           | <a href="https://www.tandfonline.com/doi/abs/10.3109/07388558409082583?journalCode=ibty20">https://www.tandfonline.com/doi/abs/10.3109/07388558409082583?journalCode=ibty20</a>           |           |
| 4.                           | <a href="https://wew.sciencedirect.com/topics/neuroscience/microbial-respiration">https://wew.sciencedirect.com/topics/neuroscience/microbial-respiration.</a>                            |           |
| 5.                           | <a href="https://www.britannica.com/science/photosynthesis">https://www.britannica.com/science/photosynthesis.</a>                                                                        |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                                                           |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                                      | 25 Marks  |
|                              | Assignments                                                                                                                                                                               |           |
|                              | Seminars                                                                                                                                                                                  |           |
|                              | Attendance and Class Participation                                                                                                                                                        |           |
| External Evaluation          | End Semester Examination                                                                                                                                                                  | 75 Marks  |
|                              | Total                                                                                                                                                                                     | 100 Marks |

| <b>Methods of Assessment</b> |                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

### Mapping with Programme Outcomes

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-------|-------|-------|
| CO1 | S   |     |     | M   |     | M   | S   |     | S   |       |       |       |       |       |
| CO2 | S   |     |     | S   | M   | S   |     |     | S   |       |       |       |       |       |
| CO3 |     |     |     | S   |     | S   | S   | S   | S   | M     |       |       |       |       |
| CO4 |     |     |     | S   | M   | S   | M   |     | S   | M     |       |       |       |       |
| CO5 |     |     |     | S   | M   | S   | M   |     | S   | S     |       |       |       |       |

| Subject Code             | Subject Name                                                                     | Category                    | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------------------|----------------------------------------------------------------------------------|-----------------------------|---|---|---|---|---------|-------------|-------|----------|-------|
|                          |                                                                                  |                             |   |   |   |   |         |             | CIA   | External | Total |
| 22MBP GCP1               | Practical I – General Microbiology, Microbial Diversity and Microbial Physiology | Core Course III-Practical I | - | - | Y | - | 4       | 6           | 60    | 40       | 100   |
| <b>Course Objectives</b> |                                                                                  |                             |   |   |   |   |         |             |       |          |       |

| CO1             | Gain knowledge on the fundamentals, handling and applications of microscopy,                                                                                                                                                                                                                                                              |                               |                   |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-------------------|
| CO2             | Provide fundamental skills in sterilization methods. Identify microbes by different staining methods.                                                                                                                                                                                                                                     |                               |                   |
| CO3             | Prepare media for bacterial growth. Analyze microbial enzymes.                                                                                                                                                                                                                                                                            |                               |                   |
| CO4             | Perform plating techniques and methods involved in microbial preservation.                                                                                                                                                                                                                                                                |                               |                   |
| CO5             | Measure bacterial growth, identify optimal growth parameters, cultivate bacteria, and perform antibiotic sensitivity.                                                                                                                                                                                                                     |                               |                   |
| UNIT            | Details                                                                                                                                                                                                                                                                                                                                   | No. of Hours                  | Course Objectives |
| I               | Microscopic Techniques: Light microscopy: Hay infusion broth. Wet mount to show different types of microbes, hanging drop. Micrometry.<br>Dark field microscopy – Motility of Spirochetes.<br>Washing and cleaning of glass wares: Sterilization methods: moist heat, dry heat, and filtration.<br>Quality control check for each method. | 20                            | CO1               |
| II              | Staining techniques - Simple staining, Gram's staining, Acid fast staining, Meta chromatic granule staining, Spore, Capsule, Flagella.                                                                                                                                                                                                    | 20                            | CO2               |
| III             | Media Preparation: Preparation of liquid, solid and semisolid media. Agar deeps, slants, plates. Preparation of basal, enriched, selective and enrichment media.<br>Preparation of Biochemical test media, media to demonstrate enzymatic activities.                                                                                     | 20                            | CO3               |
| IV              | Purification and maintenance of microbes. Streak plate, pour plate, and slide culture technique. Aseptic transfer.<br>Direct counts – Total cell count, Turbidometry. Viable count - pour plate, spread plate                                                                                                                             | 10                            | CO4               |
| V               | Bacterial growth curve. Effect of physical and chemical factors on growth. Anaerobic culture methods.                                                                                                                                                                                                                                     | 20                            | CO5               |
|                 | Total                                                                                                                                                                                                                                                                                                                                     | 60                            |                   |
| Course Outcomes |                                                                                                                                                                                                                                                                                                                                           |                               |                   |
| Course Outcomes | On completion of this course, students will;                                                                                                                                                                                                                                                                                              |                               |                   |
| CO1             | Apply microscopic techniques and staining methods in the identification and differentiation of microbes.                                                                                                                                                                                                                                  | PO1, PO6, PO7, PO8, PO9, PO11 |                   |
| CO2             | Apply the knowledge on the sterilization of glass wares and media by different methods and measurement of cell                                                                                                                                                                                                                            | PO1, PO6, PO7, PO8, PO9, PO11 |                   |

|                              |                                                                                                                                                                    |                          |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
|                              | growth.                                                                                                                                                            |                          |
| CO3                          | Prepare media for bacterial growth. Analyze microbial enzymes.                                                                                                     | PO5, PO7, PO8, PO9, PO11 |
| CO4                          | Pertain plating techniques and methods involved in microbial preservation.                                                                                         | PO6, PO7, PO8, PO9, PO11 |
| CO5                          | Analyze microbial growth, optimal growth parameters, cultivate bacteria, and perform antibiotic sensitivity.                                                       | PO6, PO7, PO8, PO9, PO11 |
| <b>Text Books</b>            |                                                                                                                                                                    |                          |
| 1.                           | Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand.                                                                                          |                          |
| 2.                           | Cappuccino, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6 <sup>th</sup> Edition). Pearson Education, Publication, New Delhi.                    |                          |
| 3.                           | Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2 <sup>nd</sup> Edition). - Taylor & Francis.                                               |                          |
| 4.                           | Moat, A.G. Foster, J.W. and Spector, M. P (2002) Microbial Physiology, 4 <sup>th</sup> Edn. Wiley - Liss, New York.                                                |                          |
| 5.                           | Dawes, I. W. and Sutherland, I. W (1992) Microbial physiology, 2 <sup>nd</sup> Edn. Black-well Scientific Publications, London.                                    |                          |
| <b>References Books</b>      |                                                                                                                                                                    |                          |
| 1.                           | Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14 <sup>th</sup> Edition). Elsevier, New Delhi. |                          |
| 2.                           | Stanier R.Y., Ingraham, J.L., Wheelis, M.L and Painter, P.R. (2010). General Microbiology. 5th Edn. Macmilan education Ltd. London.                                |                          |
| 3.                           | Prescott. L.M., Harley. J.P., Klein. D.A. (1993). Microbiology. 2 <sup>nd</sup> edn. Wm. C. Brown publishers, Dubugue.                                             |                          |
| 4.                           | Gottschalk, G. (1986). Bacterial Metabolism. 2 <sup>nd</sup> Edn. Springer-Verlag, New York.                                                                       |                          |
| 5.                           | Rose, A.H. (1976). An Introduction to Microbial Physiology. 3 <sup>rd</sup> Edn. Plenum, New York.                                                                 |                          |
| <b>Web Resources</b>         |                                                                                                                                                                    |                          |
| 1.                           | <a href="http://textbookofbacteriology.net/">http://textbookofbacteriology.net/</a>                                                                                |                          |
| 2.                           | <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/</a>                                            |                          |
| 3.                           | <a href="http://sciencenetlinks.com/tools/microbeworld">http://sciencenetlinks.com/tools/microbeworld</a>                                                          |                          |
| 4.                           | <a href="https://www.microbes.info/">https://www.microbes.info/</a>                                                                                                |                          |
| 5.                           | <a href="https://www.asmscience.org/VisualLibrary">https://www.asmscience.org/VisualLibrary</a>                                                                    |                          |
| <b>Methods of Evaluation</b> |                                                                                                                                                                    |                          |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                               | 40 Marks                 |
|                              | Attendance and Class Participation                                                                                                                                 |                          |
| External Evaluation          | End Semester Examination                                                                                                                                           | 60 Marks                 |
|                              | Total                                                                                                                                                              | 100 Marks                |

| <b>Methods of Assessment</b> |                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

### Mapping with Programme Outcomes

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| CO1 | M   |     |     |     |     | S   | M   | M   | S   |      | M    |      |      |      |
| CO2 | M   |     |     |     |     | S   | M   | M   | S   |      | M    |      |      |      |
| CO3 |     |     |     |     | S   |     | S   | M   | S   |      | M    |      |      |      |
| CO4 |     |     |     |     |     | S   | S   | M   | S   |      | S    |      |      |      |
| CO5 |     |     |     |     |     | S   | S   | M   | S   |      | S    |      |      |      |

| Subject Code      | Subject Name                                                                                                                                                                                                                                | Category                      | L | T | P | S | Credits | Inst. Hours | Marks |              |                   |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---|---|---|---|---------|-------------|-------|--------------|-------------------|
|                   |                                                                                                                                                                                                                                             |                               |   |   |   |   |         |             | CIA   | External     | Total             |
| 22MBPGE 1A        | Forensic Science                                                                                                                                                                                                                            | Elective Course I (Choice -1) | 3 | 1 | - | - | 3       | 4           | 25    | 75           | 100               |
| Course Objectives |                                                                                                                                                                                                                                             |                               |   |   |   |   |         |             |       |              |                   |
| CO1               | Understand the Scope, need and learn the tools and techniques in forensic science.                                                                                                                                                          |                               |   |   |   |   |         |             |       |              |                   |
| CO2               | Comprehend organizational setup of a forensic science laboratory.                                                                                                                                                                           |                               |   |   |   |   |         |             |       |              |                   |
| CO3               | Identify and Examine body fluids for identification.                                                                                                                                                                                        |                               |   |   |   |   |         |             |       |              |                   |
| CO4               | Extract DNA from blood samples for investigation.                                                                                                                                                                                           |                               |   |   |   |   |         |             |       |              |                   |
| CO5               | Recognize medico legal post mortem procedures and their importance.                                                                                                                                                                         |                               |   |   |   |   |         |             |       |              |                   |
| UNIT              | Details                                                                                                                                                                                                                                     |                               |   |   |   |   |         |             |       | No. of Hours | Course Objectives |
| I                 | Forensic Science - Definition, history and development of forensic science. Scope and need of forensic science in present scenario. Branches of forensic science. Tools and techniques of forensic science. Duties of a forensic scientist. |                               |   |   |   |   |         |             |       | 12           | CO1               |

|                        |                                                                                                                                                                                                                                                                                               |                         |     |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----|
| II                     | Forensic science laboratories - Organizational setup of a forensic science laboratory. Central and State level laboratories in India. Mobile forensic science laboratory and its functions. Forensic microbiology - Types and identification of microbial organisms of forensic significance. | 12                      | CO2 |
| III                    | Forensic serology - Definition, identification and examination of body fluids - Blood, semen, saliva, sweat and urine. Forensic examination and identification of hair and fibre.                                                                                                             | 12                      | CO3 |
| IV                     | DNA profiling - Introduction, history of DNA typing. Extraction of DNA from blood samples - Organic and Inorganic extraction methods. DNA fingerprinting - RFLP, PCR, STR. DNA testing in disputed paternity.                                                                                 | 12                      | CO4 |
| V                      | Forensic toxicology - Introduction and concept of forensic toxicology. Medico legal post mortem and their examination. Poisons - Types of poisons and their mode of action.                                                                                                                   | 12                      | CO5 |
|                        | Total                                                                                                                                                                                                                                                                                         | 60                      |     |
| <b>Course Outcomes</b> | On completion of this course, students will;                                                                                                                                                                                                                                                  |                         |     |
| CO1                    | Identify the scope and need of forensic science in the present scenario.                                                                                                                                                                                                                      | PO1, PO6, PO7, PO8, PO9 |     |
| CO2                    | Plan for the organizational setup and functioning of forensic science laboratories.                                                                                                                                                                                                           | PO1, PO6, PO7, PO8, PO9 |     |
| CO3                    | Analyze the biological samples found at the crime scene.                                                                                                                                                                                                                                      | PO1, PO5, PO7, PO8, PO9 |     |
| CO4                    | Perform extraction and identification of DNA obtained from body fluids.                                                                                                                                                                                                                       | PO1, PO6, PO7, PO8, PO9 |     |
| CO5                    | Discuss the concept of forensic toxicology.                                                                                                                                                                                                                                                   | PO1, PO6, PO7, PO8, PO9 |     |
| <b>Text Books</b>      |                                                                                                                                                                                                                                                                                               |                         |     |
| 1.                     | Nanda B. B. and Tewari R. K. (2001) Forensic Science in India: A Vision for the Twenty First Century. Select Publishers, New Delhi. ISBN- 10:8190113526 / ISBN-13:9788190113526.                                                                                                              |                         |     |
| 2.                     | James S. H. and Nordby, J. J. (2015) Forensic Science: An Introduction to Scientific and Investigative Techniques. (5 <sup>th</sup> Edition). CRC Press. ISBN-10:9781439853832 / ISBN-13:978-1439853832.                                                                                      |                         |     |
| 3.                     | Li R. (2015) Forensic Biology. (2 <sup>nd</sup> Edition). CRC Press, New York. ISBN-13:978-1-4398-8972-5.                                                                                                                                                                                     |                         |     |
| 4.                     | Sharma B.R (2020) Forensic science in criminal investigation and trials. (6 <sup>th</sup> Edition)Universal Press.                                                                                                                                                                            |                         |     |
| 5.                     | Richard Saferstein (2017). Criminalistics- An introduction to Forensic Science. (12 <sup>th</sup> Edition).Pearson Press.                                                                                                                                                                     |                         |     |



| Reference books       |                                                                                                                                                                                   |           |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1.                    | Nordby J. J. (2000). Dead Reckoning. The Art of Forensic Detection- CRC Press, New York. ISBN:0-8493-8122-3.                                                                      |           |
| 2.                    | Saferstein R. and Hall A. B. (2020). Forensic Science Hand book, Vol. I, (3 <sup>rd</sup> Edition). CRC Press, New York. ISBN-10:1498720196.                                      |           |
| 3.                    | Lincoln, P.J. and Thomson, J. (1998). (2 <sup>nd</sup> Edition). Forensic DNA Profiling Protocols. Vol. 98. Humana Press. ISBN: 978-0-89603-443-3.                                |           |
| 4.                    | Val McDermid (2014). Forensics. (2 <sup>nd</sup> Edition). ISBN 9780802125156.                                                                                                    |           |
| 5.                    | Vincent J. DiMaio., Dominick DiMaio. (2001). Forensic Pathology (2 <sup>nd</sup> Edition). CRC Press.                                                                             |           |
| Web resources         |                                                                                                                                                                                   |           |
| 1.                    | <a href="http://clsjournal.ascls.org/content/25/2/114">http://clsjournal.ascls.org/content/25/2/114</a>                                                                           |           |
| 2.                    | <a href="https://www.ncbi.nlm.nih.gov/books/NBK234877/">https://www.ncbi.nlm.nih.gov/books/NBK234877/</a>                                                                         |           |
| 3.                    | <a href="https://www.elsevier.com/books/microbial-forensics/budowle/978-0-12-382006-8">https://www.elsevier.com/books/microbial-forensics/budowle/978-0-12-382006-8</a>           |           |
| 4.                    | <a href="https://www.researchgate.net/publication/289542469_Methods_in_microbial_forensics">https://www.researchgate.net/publication/289542469_Methods_in_microbial_forensics</a> |           |
| 5.                    | <a href="https://cisac.fsi.stanford.edu/events/microbial_forensics">https://cisac.fsi.stanford.edu/events/microbial_forensics</a>                                                 |           |
| Methods of Evaluation |                                                                                                                                                                                   |           |
| Internal Evaluation   | Continuous Internal Assessment Tests                                                                                                                                              | 25 Marks  |
|                       | Assignments                                                                                                                                                                       |           |
|                       | Seminars                                                                                                                                                                          |           |
|                       | Attendance and Class Participitation                                                                                                                                              |           |
| External Evaluation   | End Semester Examination                                                                                                                                                          | 75 Marks  |
|                       | Total                                                                                                                                                                             | 100 Marks |

| Methods of Assessment        |                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |

|             |                                                                                          |
|-------------|------------------------------------------------------------------------------------------|
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |
|-------------|------------------------------------------------------------------------------------------|

### Mapping with Programme Outcomes

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-------|-------|-------|
| CO1 | L   |     |     |     |     | S   | M   | M   | S   |       |       |       |       |       |
| CO2 | M   |     |     |     |     | S   | M   | M   | S   |       |       |       |       |       |
| CO3 | L   |     |     |     | S   |     | S   | M   | S   |       |       |       |       |       |
| CO4 | M   |     |     |     |     | S   | S   | M   | S   |       |       |       |       |       |
| CO5 | M   |     |     |     |     | S   | S   | M   | S   |       |       |       |       |       |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                                                         | Category                      | L | T | P | S | Credits | Inst. Hours | Marks               |                          |       |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---|---|---|---|---------|-------------|---------------------|--------------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                      |                               |   |   |   |   |         |             | CIA                 | External                 | Total |
| 22MBP GE4B               | Nanobiotechnology                                                                                                                                                                                                                                                                                                                                                                                    | Elective Course IV (Choice 2) | Y | Y | - | - | 3       | 4           | 25                  | 75                       | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                      |                               |   |   |   |   |         |             |                     |                          |       |
| CO1                      | Analyze nanomaterials based on the understanding of nanobiotechnology.                                                                                                                                                                                                                                                                                                                               |                               |   |   |   |   |         |             |                     |                          |       |
| CO2                      | Discuss the methods of fabrication of nanomaterials.                                                                                                                                                                                                                                                                                                                                                 |                               |   |   |   |   |         |             |                     |                          |       |
| CO3                      | Gain Knowledge on characterization of nanomaterials.                                                                                                                                                                                                                                                                                                                                                 |                               |   |   |   |   |         |             |                     |                          |       |
| CO4                      | Discover nanomaterials for targeted drug delivery.                                                                                                                                                                                                                                                                                                                                                   |                               |   |   |   |   |         |             |                     |                          |       |
| CO5                      | Explain nanomaterials in nanomedicine and environmental pollution.                                                                                                                                                                                                                                                                                                                                   |                               |   |   |   |   |         |             |                     |                          |       |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                                                       |                               |   |   |   |   |         |             | <b>No. of Hours</b> | <b>Course Objectives</b> |       |
| I                        | Introduction to nanobiotechnology, Nano size-changing phenomena at nano scale, Classification of nanomaterials based on their dimensions (0D, 1D, 2D and 3D materials) and based on realization of their applications (The First, second, third and fourth generation materials), Class of nanomaterials and their applications. Need for nanomaterials and the risks associated with the materials. |                               |   |   |   |   |         |             | 12                  | CO1                      |       |
| II                       | Fabrication of Nanomaterials-Top-down and Bottom-up approaches, Solid phase synthesis-milling, Liquid phase synthesis-Sol-gel synthesis, colloidal synthesis, micro emulsion method, hydrothermal synthesis and solvo thermal synthesis, Vapour/Gas phase synthesis-Inert gas condensation, flame pyrolysis, Laser ablation and plasma synthesis techniques. Microbial synthesis of nanoparticles.   |                               |   |   |   |   |         |             | 12                  | CO2                      |       |
| III                      | Characterization of nanoparticles – Based on particle size/morphology- Dynamic light scattering (DLS), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), Based on surface charge-zeta potential, Based on structure –X-ray diffraction (XRD), Fourier transform infrared spectroscopy                                                       |                               |   |   |   |   |         |             | 12                  | CO3                      |       |

|                        |                                                                                                                                                                                                                                                                                                                                            |                         |     |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----|
|                        | (FTIR), Energy dispersive X-ray analysis (EDX),Based on optical properties- UV – Spectrophotometer, Based on magnetic properties-Vibrating sample magnetometer(VSM).                                                                                                                                                                       |                         |     |
| IV                     | Nanomaterial based Drug delivery and therapeutics-surface modified nano particles, MEMS/NEMS based devices, peptide/DNA coupled nanoparticles, lipid and inorganic nano particles for drug delivery, Metal/metaloxyde nano particles as antibacterial, antifungal and antiviral agents. Toxicity of nanoparticles and Toxicity Evaluation. | 12                      | CO4 |
| V                      | Nanomaterials in diagnosis-Imaging, nanosensors in detection of pathogens. Treatment of surface water, ground water and waste water contaminated by toxic metal ions, organic and inorganic solutes and microorganisms.                                                                                                                    | 12                      | CO5 |
|                        | Total                                                                                                                                                                                                                                                                                                                                      | 60                      |     |
| <b>Course Outcomes</b> |                                                                                                                                                                                                                                                                                                                                            |                         |     |
| <b>Course Outcomes</b> | On completion of this course, students will;                                                                                                                                                                                                                                                                                               |                         |     |
| CO1                    | Employ knowledge in the field of nanobiotechnology for development.                                                                                                                                                                                                                                                                        | PO1, PO9                |     |
| CO2                    | Identify various applications of nanomaterials in the field of medicine and environment.                                                                                                                                                                                                                                                   | PO1, PO9                |     |
| CO3                    | Examine the prospects and significance of nanobiotechnology.                                                                                                                                                                                                                                                                               | PO1, PO6, PO11          |     |
| CO4                    | Identify recent advances in this area and create a career or pursue research in the field.                                                                                                                                                                                                                                                 | PO1, PO5, PO7, PO9      |     |
| CO5                    | Design non-toxic nanoparticles for targeted drug delivery.                                                                                                                                                                                                                                                                                 | PO1,PO5, PO7, PO9, PO11 |     |
| <b>Text Books</b>      |                                                                                                                                                                                                                                                                                                                                            |                         |     |
| 1.                     | Brydson R. M., Hammond, C. (2005). Generic Methodologies for Nanotechnology: Characterization. In Nanoscale Science and Technology. John Wiley & Sons, Ltd.                                                                                                                                                                                |                         |     |
| 2.                     | Leggett G. J., Jones R. A. L. (2005). Bionanotechnology. In Nanoscale Science and Technology. John Wiley & Sons, Ltd.                                                                                                                                                                                                                      |                         |     |
| 3.                     | Mohan Kumar G. (2016). Nanotechnology: Nanomaterials and nanodevices. Narosa Publishing House.                                                                                                                                                                                                                                             |                         |     |
| 4.                     | Goodsell D. S. (2004). Bionanotechnology. John Wiley & Sons, Inc.                                                                                                                                                                                                                                                                          |                         |     |
| 5.                     | Pradeep T. (2007). Nano: The Essentials-Understanding nanoscience and nanotechnology. Tata McGraw-Hill.                                                                                                                                                                                                                                    |                         |     |
|                        | <b>References Books</b>                                                                                                                                                                                                                                                                                                                    |                         |     |
| 1.                     | Nouailhat A. (2008). An Introduction to Nanoscience and Nanotechnology, Wiley.                                                                                                                                                                                                                                                             |                         |     |
| 2.                     | Sharon M. and Maheshwar (2012). Bio-Nanotechnology: Concepts and Applications. New Delhi. Ane books Pvt Ltd.                                                                                                                                                                                                                               |                         |     |
| 3.                     | Niemeyer C.M. and Mirkin C. A. (2005). Nanobiotechnology. Wiley Interscience.                                                                                                                                                                                                                                                              |                         |     |

|                               |                                                                                                                                               |           |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 4.                            | Rehm, B. (2006). Microbial Bionanotechnology: Biological Self-Assembly Systems and Biopolymer-Based Nanostructures. Horizon Scientific Press. |           |
| 5..                           | Reisner, D.E. (2009). Bionanotechnology: Global Prospects. CRC Press                                                                          |           |
| Web Resources                 |                                                                                                                                               |           |
| 1.                            | <a href="https://www.gale.com/nanotechnology">https://www.gale.com/nanotechnology</a>                                                         |           |
| 2.                            | <a href="https://www.understandingnano.com/resources.html">https://www.understandingnano.com/resources.html</a>                               |           |
| 3.                            | <a href="http://dbtnanobiotech.com/index2.php">http://dbtnanobiotech.com/index2.php</a>                                                       |           |
| 4.                            | <a href="http://www.istl.org/11-winter/internet1.html">http://www.istl.org/11-winter/internet1.html</a>                                       |           |
| 5.                            | <a href="https://www.cdc.gov/niosh/topics/nanotech/default.html">https://www.cdc.gov/niosh/topics/nanotech/default.html</a>                   |           |
| Methods of Evaluation         |                                                                                                                                               |           |
| Internal Evaluation           | Continuous Internal Assessment Tests                                                                                                          | 25 Marks  |
|                               | Assignments                                                                                                                                   |           |
|                               | Seminars                                                                                                                                      |           |
|                               | Attendance and Class Participation                                                                                                            |           |
| External Evaluation           | End Semester Examination                                                                                                                      | 75 Marks  |
|                               | Total                                                                                                                                         | 100 Marks |
| Methods of Assessment         |                                                                                                                                               |           |
| Recall (KI)                   | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                    |           |
| Understand/ Comprehended (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                |           |
| Application (K3)              | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                        |           |
| Analyse (K4)                  | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                               |           |
| Evaluate (K5)                 | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                                        |           |
| Create (K6)                   | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                                      |           |

#### Mapping with Programme Outcomes

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| CO1 | S   |     |     | M   |     |     |     |     | M   |      |      |      |      |      |
| CO2 | S   |     |     |     |     |     |     |     | S   |      |      |      |      |      |

|     |   |  |  |  |   |   |   |  |   |  |   |  |  |  |
|-----|---|--|--|--|---|---|---|--|---|--|---|--|--|--|
| CO3 | S |  |  |  |   | M |   |  |   |  | S |  |  |  |
| CO4 | S |  |  |  | S |   | M |  | S |  |   |  |  |  |
| CO5 | S |  |  |  | S |   | M |  | S |  | S |  |  |  |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Category                      | L | T | P | S | Credits | Inst. Hours | Marks        |                   |       |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---|---|---|---|---------|-------------|--------------|-------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                               |   |   |   |   |         |             | CIA          | External          | Total |
| 22MBP GE1C               | Microalgal Technology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Elective Course I (Choice -3) | Y | Y | - | - | 3       | 4           | 25           | 75                | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                               |   |   |   |   |         |             |              |                   |       |
| CO1                      | Characterize the different groups of algae.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                               |   |   |   |   |         |             |              |                   |       |
| CO2                      | Describe the cultivation and harvesting of algae.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                               |   |   |   |   |         |             |              |                   |       |
| CO3                      | Identify the commercial applications of various algal products.                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                               |   |   |   |   |         |             |              |                   |       |
| CO4                      | Apply microalgae for environmental applications.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                               |   |   |   |   |         |             |              |                   |       |
| CO5                      | Employ microalgae as alternate fuels.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                               |   |   |   |   |         |             |              |                   |       |
| UNIT                     | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                               |   |   |   |   |         |             | No. of Hours | Course Objectives |       |
| I                        | Introduction to Algae - General characteristics. Classification of algae according to Fritsch. Salient features of different groups of algae. Distribution - Freshwater, brackish water and marine algae. Identification methods. An overview of applied Phycology. Economically important microalgae.                                                                                                                                                                                                                  |                               |   |   |   |   |         |             | 12           | CO1               |       |
| II                       | Cultivation of freshwater and marine microalgae - Growth media. Isolation and enumeration of microalgae. Laboratory cultivation and maintenance. Outdoor cultivation - Photobioreactors - construction, types and operation; raceway ponds - Heterotrophic and mixotrophic cultivation - Harvesting of microalgae biomass.                                                                                                                                                                                              |                               |   |   |   |   |         |             | 12           | CO2               |       |
| III                      | Microalgae in food and nutraceutical applications - Algal single cell proteins. Cultivation of <i>Spirulina</i> and <i>Dunaliella</i> . Microalgae as aquatic, poultry and cattle feed. Microalgal biofertilizers. Value-added products from microalgae. Pigments - Production of microalgal carotenoids and their uses. Phycobiliproteins - production and commercial applications. Polyunsaturated fatty acids as active nutraceuticals. Microalgal secondary metabolites - Pharmaceutical and cosmetic applications. |                               |   |   |   |   |         |             | 12           | CO3               |       |
| IV                       | Microalgae in environmental applications. Phycoremediation - Domestic and industrial waste water treatment. High-rate algal ponds and surface-immobilized systems - Treatment of gaseous wastes by microalgae. Sequestration of carbon dioxide. Scavenging of heavy metals by microalgae. Negative effects of algae. Algal                                                                                                                                                                                              |                               |   |   |   |   |         |             | 12           | CO4               |       |

|                  |                                                                                                                                                                                                                                                                                                                                                                                |                      |     |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----|
|                  | blooms, algicides for algal control.                                                                                                                                                                                                                                                                                                                                           |                      |     |
| V                | Microalgae as feed stock for production of biofuels - Carbon-neutral fuels. Lipid-rich algal strains - <i>Botryococcus braunii</i> . Drop-in fuels from algae - hydrocarbons and biodiesel, bioethanol, biomethane, biohydrogen and syngas from microalgae biomass. Biocrude synthesis from microalgae. Integrated biorefinery concept. Life cycle analysis of algae biofuels. | 12                   | CO5 |
|                  | Total                                                                                                                                                                                                                                                                                                                                                                          | 60                   |     |
| Course Outcomes  |                                                                                                                                                                                                                                                                                                                                                                                |                      |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                   |                      |     |
| CO1              | Acquire knowledge in the field of microalgal technology and their characteristics.                                                                                                                                                                                                                                                                                             | PO1                  |     |
| CO2              | Identify the methods of algal cultivation and harvesting.                                                                                                                                                                                                                                                                                                                      | PO1, PO6             |     |
| CO3              | Recognize and recommend the use of microalgae as food, feed and fodder.                                                                                                                                                                                                                                                                                                        | PO7, PO8, PO9        |     |
| CO4              | Promote microalgae in phycoremediation.                                                                                                                                                                                                                                                                                                                                        | PO7, PO9, PO11, PO14 |     |
| CO5              | Compare and critically evaluate recent applied research in these microalgal applications.                                                                                                                                                                                                                                                                                      | PO7, PO8, PO9        |     |
| Text Books       |                                                                                                                                                                                                                                                                                                                                                                                |                      |     |
| 1.               | Lee R.E. (2008). Phycology. Cambridge University Press.                                                                                                                                                                                                                                                                                                                        |                      |     |
| 2.               | Sharma O.P. (2011). Algae. Tata McGraw-Hill Education.                                                                                                                                                                                                                                                                                                                         |                      |     |
| 3.               | Shekh A., Schenk P., Sarada R. (2021). Microalgal Biotechnology. Recent Advances, Market Potential and Sustainability. Royal Society of Chemistry.                                                                                                                                                                                                                             |                      |     |
| 4.               | Lele. S.S., Jyothi Kishen Kumar (2008). Algal bio process technology. New Age International P(Ltd)                                                                                                                                                                                                                                                                             |                      |     |
| 5.               | Das., Mihirkumar. Algal Biotechnology. Daya Publishing House, New Delhi.                                                                                                                                                                                                                                                                                                       |                      |     |
| References Books |                                                                                                                                                                                                                                                                                                                                                                                |                      |     |
| 1                | Andersen R.A. (2005). Algal culturing techniques. Academic Press, Elsevier.                                                                                                                                                                                                                                                                                                    |                      |     |
| 2                | Bux F. (2013). Biotechnological Applications of Microalgae: Biodiesel and Value-added Products. CRC Press.                                                                                                                                                                                                                                                                     |                      |     |
| 3                | Singh B., Bauddh K., Bux, F. (2015). Algae and Environmental Sustainability. Springer.                                                                                                                                                                                                                                                                                         |                      |     |
| 4                | Das D. (2015). An algal biorefinery: An integrated approach. Springer.                                                                                                                                                                                                                                                                                                         |                      |     |
| 5                | Bux F. and Chisti Y. (2016). Algae Biotechnology: Products and Processes. Springer.                                                                                                                                                                                                                                                                                            |                      |     |
| Web Resources    |                                                                                                                                                                                                                                                                                                                                                                                |                      |     |
| 1                | <a href="https://www.classcentral.com/course/algae-10442">https://www.classcentral.com/course/algae-10442</a>                                                                                                                                                                                                                                                                  |                      |     |
| 2                | <a href="https://onlinecourses.nptel.ac.in/noc19_bt16/preview">https://onlinecourses.nptel.ac.in/noc19_bt16/preview</a>                                                                                                                                                                                                                                                        |                      |     |
| 3                | <a href="https://freevidelectures.com/course/4678/nptel-industrial-biotechnology/46">https://freevidelectures.com/course/4678/nptel-industrial-biotechnology/46</a>                                                                                                                                                                                                            |                      |     |
| 4                | <a href="https://nptel.ac.in/courses/103103207">https://nptel.ac.in/courses/103103207</a>                                                                                                                                                                                                                                                                                      |                      |     |



|                              |                                                                                                                                                                         |           |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 5.                           | <a href="https://www.sciencedirect.com/topics/earth-and-planetary-sciences/microalgae">https://www.sciencedirect.com/topics/earth-and-planetary-sciences/microalgae</a> |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                                         |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                    | 25 Marks  |
|                              | Assignments                                                                                                                                                             |           |
|                              | Seminars                                                                                                                                                                |           |
|                              | Attendance and Class Participitation                                                                                                                                    |           |
| External Evaluation          | End Semester Examination                                                                                                                                                | 75 Marks  |
|                              | Total                                                                                                                                                                   | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                                                                         |           |
| Recall (KI)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                              |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                          |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                                  |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                                         |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                                                                  |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                                                                |           |

### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | S    |      |      |      |      |      |      |      |      |       |       |       |       |       |
| CO2 | S    |      |      |      |      | M    |      |      |      |       |       |       |       |       |
| CO3 |      |      |      |      |      |      | S    | S    | S    |       |       |       |       |       |
| CO4 |      |      |      |      |      |      | S    |      | S    |       | M     |       |       | M     |
| CO5 |      |      |      |      |      |      | M    | S    | S    |       |       |       |       |       |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                                                                                                         | Category                       | L | T | P | S | Credits | Inst. Hours | Marks               |                          |       |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|---|---|---|---|---------|-------------|---------------------|--------------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                |   |   |   |   |         |             | CIA                 | External                 | Total |
| 22MB PGE2 A              | Bioinstrumentation                                                                                                                                                                                                                                                                                                                                                                                                                                   | Elective Course II (Choice -1) | Y | Y | - | - | 3       | 4           | 25                  | 75                       | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                |   |   |   |   |         |             |                     |                          |       |
| CO1                      | Explain the principles and working mechanisms of laboratory instruments.                                                                                                                                                                                                                                                                                                                                                                             |                                |   |   |   |   |         |             |                     |                          |       |
| CO2                      | Discuss chromatography techniques and molecular biology techniques.                                                                                                                                                                                                                                                                                                                                                                                  |                                |   |   |   |   |         |             |                     |                          |       |
| CO3                      | Illustrate molecular techniques in biological applications.                                                                                                                                                                                                                                                                                                                                                                                          |                                |   |   |   |   |         |             |                     |                          |       |
| CO4                      | Acquire knowledge on spectroscopic techniques                                                                                                                                                                                                                                                                                                                                                                                                        |                                |   |   |   |   |         |             |                     |                          |       |
| CO5                      | Demonstrate the use of radio isotopes in various techniques.                                                                                                                                                                                                                                                                                                                                                                                         |                                |   |   |   |   |         |             |                     |                          |       |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                |   |   |   |   |         |             | <b>No. of Hours</b> | <b>Course Objectives</b> |       |
| I                        | Basic laboratory Instruments. Aerobic and anaerobic incubator – Biosafety Cabinets - Fume Hood, pH meter, Lyophilizer, Flow cytometry. Centrifugation techniques: Basic principles of centrifugation - Standard sedimentation coefficient - measurement of sedimentation co-efficient; Principles, methodology and applications of differential, rate zonal and density gradient centrifugation - Applications in determination of molecular weight. |                                |   |   |   |   |         |             | 12                  | CO1                      |       |
| II                       | General principles of chromatography - Chromatographic Performance parameters; Types- Thin layer chromatography, Paper Chromatography, Liquid chromatography (LPLC &HPLC), Adsorption, ion exchange, Gel filtration, affinity, Gas liquid (GLC). Flash Chromatography and Ultra Performance convergence                                                                                                                                              |                                |   |   |   |   |         |             | 12                  | CO2                      |       |

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |     |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----|
|                 | chromatography. Two dimensional chromatography. Stimulated moving bed chromatography (SEC).                                                                                                                                                                                                                                                                                                                                              |                         |     |
| III             | Electrophoresis: Principle and applications - paper electrophoresis, Serum electrophoresis, starch gel electrophoresis, Disc gel, Agarose gel, SDS – PAGE, Immuno electrophoresis. Blotting techniques -Southern, northern and western blotting.                                                                                                                                                                                         | 12                      | CO3 |
| IV              | Spectroscopic techniques: Principle, simple theory of absorption of light by molecules, electromagnetic spectrum, instrumentation and application of UV- visible, FTIR spectrophotometer, Atomic Absorption Spectrophotometer, Flame spectrophotometer, NMR, ESR, Emission Flame Photometry and GC-MS. Detection of molecules in living cells - FISH and GISH. Biophysical methods: Analysis of biomolecules by Spectroscopy UV/visible. | 12                      | CO4 |
| V               | Radioisotopic techniques: Principle and applications of tracer techniques in biology. Radioactive isotopes - radioactive decay; Detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger- Muller and Scintillation counters, auto radiography and its applications. Commonly used isotopes in biology, labeling procedures and safety aspects.                                                  | 12                      | CO5 |
|                 | Total                                                                                                                                                                                                                                                                                                                                                                                                                                    | 60                      |     |
| Course Outcomes |                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |     |
| Course Outcomes | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                             |                         |     |
| CO1             | Make use of the laboratory instruments- laminar air flow, pH meter, centrifugation methods, biosafety cabinets following SOP.                                                                                                                                                                                                                                                                                                            | PO4, PO6, PO7, PO8, P11 |     |
| CO2             | Apply chromatography techniques in the separation of biomolecules.                                                                                                                                                                                                                                                                                                                                                                       | PO4, PO6, PO7, PO8, P11 |     |
| CO3             | Perform molecular techniques like mutagenesis and their detection.                                                                                                                                                                                                                                                                                                                                                                       | PO4, PO6, PO7, PO8, P11 |     |
| CO4             | Estimate molecules in biological samples by adopting UV spectroscopic techniques.                                                                                                                                                                                                                                                                                                                                                        | PO4, PO6, PO7, PO8, P11 |     |
| CO5             | Cultivate organisms anaerobically.                                                                                                                                                                                                                                                                                                                                                                                                       | PO4, PO6, PO7, PO8, P11 |     |
| Text Books      |                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |     |
| 1.              | Sharma B. K. (2014). Instrumental Method of Chemical Analysis. Krishna Prakashan Media (P) Ltd.                                                                                                                                                                                                                                                                                                                                          |                         |     |
| 2.              | Chatwal G. R and Anand S. K. (2014.) Instrumental Methods of Chemical Analysis. Himalaya Publishing House.                                                                                                                                                                                                                                                                                                                               |                         |     |
| 3.              | Mitchell G. H. (2017). Gel Electrophoresis: Types, Applications and Research. Nova                                                                                                                                                                                                                                                                                                                                                       |                         |     |

|                              |                                                                                                                                                                                                                                                                                           |           |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|                              | Science Publishers Inc.                                                                                                                                                                                                                                                                   |           |
| 4.                           | Holme D. Peck H. (1998). Analytical Biochemistry. (3 <sup>rd</sup> Edition). Prentice Hall.                                                                                                                                                                                               |           |
| 5.                           | Jayaraman J. (2011). Laboratory Manual in Biochemistry. (2 <sup>nd</sup> Edition). Wiley Easton Ltd., New Delhi.                                                                                                                                                                          |           |
| <b>References Books</b>      |                                                                                                                                                                                                                                                                                           |           |
| 1.                           | Pavia D. L. (2012) Spectroscopy (4 <sup>th</sup> Edition). Cengage.                                                                                                                                                                                                                       |           |
| 2.                           | Skoog A. and West M. (2014). Principles of Instrumental Analysis. (14 <sup>th</sup> Edition). W.B.Saunders Co., Philadelphia.                                                                                                                                                             |           |
| 3.                           | Miller J. M. (2007). Chromatography: Concepts and Contrasts (2 <sup>nd</sup> Edition) Wiley-Blackwell.                                                                                                                                                                                    |           |
| 4.                           | Gurumani N. (2006). Research Methodology for Biological Sciences. (1 <sup>st</sup> Edition) MJP Publishers.                                                                                                                                                                               |           |
| 5.                           | Ponmurugan P. and Gangathara P. B. (2012). Biotechniques. (1 <sup>st</sup> Edition). MJP Publishers.                                                                                                                                                                                      |           |
| <b>Web Resources</b>         |                                                                                                                                                                                                                                                                                           |           |
| 1.                           | <a href="https://norcaloa.com/BMIA">https://norcaloa.com/BMIA</a>                                                                                                                                                                                                                         |           |
| 2.                           | <a href="http://www.biologydiscussion.com/biochemistry/centrifugation/centrifuge-introduction- types-uses-and-other-details-with-diagram/12489">http://www.biologydiscussion.com/biochemistry/centrifugation/centrifuge-introduction- types-uses-and-other-details-with-diagram/12489</a> |           |
| 3.                           | <a href="https://www.watelectrical.com/biosensors-types-its-working-and-applications">https://www.watelectrical.com/biosensors-types-its-working-and-applications</a> .                                                                                                                   |           |
| 4.                           | <a href="http://www.wikiscales.com/articles/electronic-analytical-balance/">http://www.wikiscales.com/articles/electronic-analytical-balance/</a>                                                                                                                                         |           |
| 5.                           | <a href="https://study.com/academy/lesson/what-is-chromatography-definition-types-uses">https://study.com/academy/lesson/what-is-chromatography-definition-types-uses</a> .                                                                                                               |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                                                                                                                                                           |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                                                                                                                                      | 25 Marks  |
|                              | Assignments                                                                                                                                                                                                                                                                               |           |
|                              | Seminars                                                                                                                                                                                                                                                                                  |           |
|                              | Attendance and Class Participation                                                                                                                                                                                                                                                        |           |
| External Evaluation          | End Semester Examination                                                                                                                                                                                                                                                                  | 75 Marks  |
|                              | Total                                                                                                                                                                                                                                                                                     | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                                                                                                                                                                                           |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                                                                                                                                                |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                                                                                                                                            |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                                                                                                                                                    |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                                                                                                                                                           |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                                                                                                                                                                                    |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                                                                                                                                                                                  |           |

### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 |      |      |      | S    |      | M    | M    | S    |      |       | S     |       |       |       |
| CO2 |      |      |      | S    |      | M    | M    | S    |      |       | S     |       |       |       |
| CO3 |      |      |      | S    |      | S    | S    | S    |      |       | S     |       |       |       |
| CO4 |      |      |      | S    |      | M    | S    | S    |      |       | S     |       |       |       |
| CO5 |      |      |      | S    |      | M    | S    | S    |      |       | L     |       |       |       |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                                                                                          | Category                      | L | T | P | S | Credits | Inst. Hours | Marks               |                          |       |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---|---|---|---|---------|-------------|---------------------|--------------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                       |                               |   |   |   |   |         |             | CIA                 | External                 | Total |
| 22MBP GE2B               | Herbal Technology and Cosmetic Microbiology                                                                                                                                                                                                                                                                                                                                                                                           | Elective Course II (Choice 2) | Y | Y | - | - | 3       | 4           | 25                  | 75                       | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                       |                               |   |   |   |   |         |             |                     |                          |       |
| CO1                      | Impart knowledge of Indian Medicinal Plants and their applications in microbiology.                                                                                                                                                                                                                                                                                                                                                   |                               |   |   |   |   |         |             |                     |                          |       |
| CO2                      | Promote the technical skills involved in preparation of different types of plant extracts.                                                                                                                                                                                                                                                                                                                                            |                               |   |   |   |   |         |             |                     |                          |       |
| CO3                      | Explain methods to analyze the antimicrobial activity of medicinal plants.                                                                                                                                                                                                                                                                                                                                                            |                               |   |   |   |   |         |             |                     |                          |       |
| CO4                      | Acquire knowledge on cosmetic microbiology and role of microorganisms in cosmetics.                                                                                                                                                                                                                                                                                                                                                   |                               |   |   |   |   |         |             |                     |                          |       |
| CO5                      | Gain insight into pharmacopeial microbial assays and biosafety.                                                                                                                                                                                                                                                                                                                                                                       |                               |   |   |   |   |         |             |                     |                          |       |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                                                                                        |                               |   |   |   |   |         |             | <b>No. of Hours</b> | <b>Course Objectives</b> |       |
| I                        | Herbs, Herbal medicine - Indian medicinal plants: Scope and Applications of Indian medicinal plants in treating bacterial, fungal and viral diseases. Basic principles involved in Ayurvedha, Sidha, Unani and Homeopathy.                                                                                                                                                                                                            |                               |   |   |   |   |         |             | 12                  | CO1                      |       |
| II                       | Collection and authentication of selected Indian medicinal plants: <i>Embllica officinalis</i> , <i>Withania somnifera</i> , <i>Phyllanthus amarus</i> , <i>Tinospora cordifolia</i> , <i>Andrographis paniculata</i> , <i>Piper longum</i> , <i>Ocimum sanctum</i> , <i>Azardirchata indica</i> , <i>Terminalia chebula</i> , <i>Allium sativum</i> . Preparation of extracts- Hot and cold methods. Preparation of stock solutions. |                               |   |   |   |   |         |             | 12                  | CO2                      |       |

|                  |                                                                                                                                                                                                                                                                                                                                                                         |               |     |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----|
| III              | Antimicrobial activity of selected Indian medicinal Plants: - In vitro determination of antibacterial and fungal activity of selected whole medicinal plants/ parts – well-diffusion methods. MIC - Macro and micro dilution techniques. Antiviral activity- cell lines- cytotoxicity, cytopathic and non-cytopathic effect.                                            | 12            | CO3 |
| IV               | History of Cosmetic Microbiology – Need for cosmetic microbiology, Scope of cosmetic microbiology, - Role of microbes in cosmetic preparation. Preservation of cosmetics. Antimicrobial properties of natural cosmetic products – Garlic, neem, turmeric, aloe vera and tulsi. Sanitary practices in cosmetic manufacturing - HACCP protocols in cosmetic microbiology. | 12            | CO4 |
| V                | Cosmetic microbiology test methods - Antimicrobial preservative efficacy, microbial content testing and biological toxicological testing. Validation methods - bioburden and Pharmacopeial microbial assays. Preservatives of cosmetics - Global regulatory and toxicological aspect of cosmetic preservatives.                                                         | 12            | CO5 |
|                  | Total                                                                                                                                                                                                                                                                                                                                                                   | 60            |     |
| Course Outcomes  |                                                                                                                                                                                                                                                                                                                                                                         |               |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                            |               |     |
| CO1              | Identify the applications of Indian medicinal plants in treating diseases.                                                                                                                                                                                                                                                                                              | PO1, PO5      |     |
| CO2              | Identify and authenticate herbal plants.                                                                                                                                                                                                                                                                                                                                | PO6, PO7      |     |
| CO3              | Evaluate the antimicrobial activity of medicinal plants.                                                                                                                                                                                                                                                                                                                | PO4, PO6, PO9 |     |
| CO4              | Describe the role of microorganisms and their metabolites in the preparation of cosmetics.                                                                                                                                                                                                                                                                              | PO1, PO5, PO7 |     |
| CO5              | Validate procedures and biosafety measures in the mass production of cosmetics.                                                                                                                                                                                                                                                                                         | PO6, PO7      |     |
| Text Books       |                                                                                                                                                                                                                                                                                                                                                                         |               |     |
| 1.               | Ayurvedic Formulary of India. (2011). Part 1, 2 & 3. Pharmacopoeia Commission for Indian Medicine and Homeopathy. ISBN-10:8190648977.                                                                                                                                                                                                                                   |               |     |
| 2.               | Panda H. (2004). Handbook on herbal medicines. Asia Pacific Business Press Inc. ISBN:8178330911.                                                                                                                                                                                                                                                                        |               |     |
| 3.               | Mehra P. S. (2019). A Textbook of Pharmaceutical Microbiology. Dreamtech Press. ISBN 13:9789389307344.                                                                                                                                                                                                                                                                  |               |     |
| 4.               | Geis P. A. (2020). Cosmetic microbiology: A Practical Approach. (3 <sup>rd</sup> Edition). CRC Press. ISBN:9780429113697.                                                                                                                                                                                                                                               |               |     |
| 5.               | Brannan D. K. (1997).Cosmetic microbiology: A Practical Handbook. CRC Press.ISBN-10:0849337135.                                                                                                                                                                                                                                                                         |               |     |
| References Books |                                                                                                                                                                                                                                                                                                                                                                         |               |     |

|                              |                                                                                                                                                                                                                                                                                                                    |           |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1.                           | Indian Herbal Pharmacopoeia (2002). Vol. I &II Indian Drug Manufacturers Association, Mumbai.                                                                                                                                                                                                                      |           |
| 2.                           | British Herbal Pharmacopoeia.(1990).Vol.I. British Herbal Medicine Association.ISBN: 0903032090.                                                                                                                                                                                                                   |           |
| 3.                           | Verpoorte R. and Mukherjee, P. K. (2010). GMP for Botanicals: Regulatory and Quality issues on Phytomedicines. In GMP for botanicals: regulatory and quality issues on phytomedicines. (2 <sup>nd</sup> edition). Saujanya Books, Delhi.ISBN-10:81-900788-5-2/8190078852. ISBN-13:978-81-900788-5-6/9788190078856. |           |
| 4.                           | Turner R. (2013). Screening methods in Pharmacology. Elsevier. ISBN:9781483264233.                                                                                                                                                                                                                                 |           |
| 5.                           | Cupp M. J. (2010). Toxicology and Clinical Pharmacology of Herbal Products (pp. 85-93). M. J. Cupp. Humana Press.Totowa, NJ, USA. ISBN-10:1617371904.                                                                                                                                                              |           |
| <b>Web Resources</b>         |                                                                                                                                                                                                                                                                                                                    |           |
| 1.                           | <a href="https://www.academia.edu/50236711/Modern_Extraction_Methods_for_Preparation_of_Bioactive_Plant_Extracts">https://www.academia.edu/50236711/Modern_Extraction_Methods_for_Preparation_of_Bioactive_Plant_Extracts</a>                                                                                      |           |
| 2.                           | <a href="https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl">https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl</a>                                                                                                                            |           |
| 3.                           | <a href="https://pubmed.ncbi.nlm.nih.gov/17004305/">https://pubmed.ncbi.nlm.nih.gov/17004305/</a>                                                                                                                                                                                                                  |           |
| 4.                           | <a href="https://www.fda.gov/cosmetics/potential-contaminants-cosmetics/microbiological-safety-and-cosmetics">https://www.fda.gov/cosmetics/potential-contaminants-cosmetics/microbiological-safety-and-cosmetics</a>                                                                                              |           |
| 5.                           | <a href="https://pubmed.ncbi.nlm.nih.gov/15156038/">https://pubmed.ncbi.nlm.nih.gov/15156038/</a>                                                                                                                                                                                                                  |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                                                                                                                                                                                    |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                                                                                                                                                               | 25 Marks  |
|                              | Assignments                                                                                                                                                                                                                                                                                                        |           |
|                              | Seminars                                                                                                                                                                                                                                                                                                           |           |
|                              | Attendance and Class Participation                                                                                                                                                                                                                                                                                 |           |
| External Evaluation          | End Semester Examination                                                                                                                                                                                                                                                                                           | 75 Marks  |
|                              | Total                                                                                                                                                                                                                                                                                                              | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                                                                                                                                                                                                                    |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                                                                                                                                                                         |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                                                                                                                                                                     |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                                                                                                                                                                             |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                                                                                                                                                                                    |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                                                                                                                                                                                                             |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                                                                                                                                                                                                           |           |

### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | M    |      |      |      | S    |      |      |      |      |       |       |       |       |       |
| CO2 |      |      |      |      |      | S    | M    |      |      |       |       |       |       |       |
| CO3 |      |      |      | S    |      | S    |      |      | M    |       |       |       |       |       |
| CO4 | M    |      |      |      | S    |      | S    |      |      |       |       |       |       |       |
| CO5 |      |      |      |      |      | M    | S    |      |      |       |       |       |       |       |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                 | Category                      | L | T | P | S | Credits | Inst. Hours | Marks               |                          |       |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---|---|---|---|---------|-------------|---------------------|--------------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                              |                               |   |   |   |   |         |             | CIA                 | External                 | Total |
| 22MBP GE2C               | Essentials of Laboratory Management and Biosafety                                                                                                                                                                                                                                                            | Elective Course II (Choice 3) | Y | Y | - | - | 3       | 4           | 25                  | 75                       | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                              |                               |   |   |   |   |         |             |                     |                          |       |
| CO1                      | To utilize containment principles to ensure biosafety.                                                                                                                                                                                                                                                       |                               |   |   |   |   |         |             |                     |                          |       |
| CO2                      | To enrich the student role and responsibilities of laboratory hazards and their control.                                                                                                                                                                                                                     |                               |   |   |   |   |         |             |                     |                          |       |
| CO3                      | To know the importance of first aid technique for various common lab accidents.                                                                                                                                                                                                                              |                               |   |   |   |   |         |             |                     |                          |       |
| CO4                      | To acquire knowledge of biosafety level, risk assessment and maintain proper hygiene in the laboratory.                                                                                                                                                                                                      |                               |   |   |   |   |         |             |                     |                          |       |
| CO5                      | To discuss the biosafety regulations and guidelines and implementation of safety programs.                                                                                                                                                                                                                   |                               |   |   |   |   |         |             |                     |                          |       |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                                               |                               |   |   |   |   |         |             | <b>No. of Hours</b> | <b>Course Objectives</b> |       |
| I                        | Introduction to the laboratory and laboratory hazards - General laboratory facilities – Occupational safety- Lab accidents - Fires, chemical burns, slips and falls, Animal bites. Cuts from broken glass. Toxic fume inhalation. General laboratory rules, Good laboratory practice (GLP). Laboratory plan. |                               |   |   |   |   |         |             | 12                  | CO1                      |       |



|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                |     |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-----|
| II                     | Common hazards in laboratory: Chemical hazards- Safe handling of chemicals and gases, hazard labels and symbols. Material safety datasheet (MSDS), Chemical handling - Fume hood, Storage of chemicals. Chemical Waste Disposal Guideline. Physical hazards - Physical agent data sheets (PADS), Electric hazards- Electrical shock, Electrical explosions, Electrical burns. Safe work practices. Potential ignition sources in the lab. Stages of Fire. Fire Extinguishers. Fire Response.                                                                           | 12                             | CO2 |
| III                    | Prevention and First aid for laboratory accidents. Personal protective equipment (PPE), Proper attire (Eye/Face Protection, laboratory coats, gloves, respirators. Disposal/Removal of PPE. Emergency equipment safety - Showers/ Eye Washes. Laboratory security and emergency response. First aid for - Injuries caused by broken glass, Acid/Alkali splashes on the skin, swallowing acid/alkali, burns caused by heat, electric shock.                                                                                                                             | 12                             | CO3 |
| IV                     | Biosafety - Historical background. Blood borne pathogens (BBP) and laboratory - acquired infections. Introduction to biological safety cabinets. Primary containment for biohazards. Biosafety levels of specific microorganisms. Recommended biosafety. Levels for infectious agents and infected animals. Risk groups with examples - Risk assessment. Safety levels. Case studies - Safe working, hand hygiene. Laboratory instruments, packing, sending, transport, import and export of biological agents. Hygiene, disinfection, decontamination, sterilization. | 12                             | CO4 |
| V                      | Biosafety regulations and guidelines. Centers for disease control and prevention and the National institutes of health. Occupational safety and health administration. Recombinant DNA advisory committee(RDAC), Institutional biosafety committee(IBSC), Review committee on genetic manipulation(RCGM), Genetic engineering approval committee (GEAC). Implementation of biosafety guidelines.                                                                                                                                                                       | 12                             | CO5 |
|                        | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 60                             |     |
| <b>Course Outcomes</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                |     |
| <b>Course Outcomes</b> | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                |     |
| CO1                    | Employ skills on laboratory safety and avoid laboratory accidents.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | PO1, PO2, PO3, PO7, PO11       |     |
| CO2                    | Prevent laboratory hazards by practicing safety strategies.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | PO2, PO5, PO7, PO11            |     |
| CO3                    | Practice various first aid procedures during common laboratory accidents.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | PO1, PO2, PO3, PO5, PO10, PO11 |     |

|                       |                                                                                                                                                                                                                                                                           |                                |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| CO4                   | Ensure biosafety strategies in laboratory.                                                                                                                                                                                                                                | PO2, PO3, PO4, PO7, PO10, PO11 |
| CO5                   | Recognize the importance of biosafety guidelines.                                                                                                                                                                                                                         | PO3, PO4, PO5, PO7, PO10, PO11 |
| Text Books            |                                                                                                                                                                                                                                                                           |                                |
| 1.                    | Sateesh M. K. (2013). Bioethics and Biosafety, IK International Pvt Ltd. ISBN : 8190675702.                                                                                                                                                                               |                                |
| 2.                    | Muthuraj M. and Usharani B. (2019). Biosafety in Microbiological Laboratories. (1st Edition). Notion Press. ISBN 10: 1645878856                                                                                                                                           |                                |
| 3.                    | Biosafety in Microbiological and Biomedical Laboratories - U.S. Health Department and Human Services. (2016). (5 <sup>th</sup> Edition). Lulu.com.                                                                                                                        |                                |
| 4.                    | Kanai. L. Mukherjee. (Medical Laboratory Technology(4 <sup>th</sup> Edition). CBS Publishers.                                                                                                                                                                             |                                |
| 5.                    | Ramakrishnan (2012). Manual of Medical Laboratory Techniques. JP brothers.                                                                                                                                                                                                |                                |
| References Books      |                                                                                                                                                                                                                                                                           |                                |
| 1.                    | World Health Organization, Biosafety programme management. (2010). (4 <sup>th</sup> Edition). WHO Publications.                                                                                                                                                           |                                |
| 2.                    | Rashid N. (2013). Manual of Laboratory Safety (Chemical, Radioactive, and Biosafety with Biocides) (1 <sup>st</sup> Edition).                                                                                                                                             |                                |
| 3                     | Dayuan X. (2015). Biosafety and Regulation for Genetically Modified Organisms, Alpha Science International Ltd, ISBN-10 : 1842657917                                                                                                                                      |                                |
| 4.                    | Ochei J. Kolhatkar(2000). A. (Medical Laboratory Science – Theory and Practice. ISBN; 13:978-0074632239.                                                                                                                                                                  |                                |
| 5.                    | Lynne S. Garcia. Clinical Laboratory Management (2 <sup>nd</sup> Edition). ASM Press                                                                                                                                                                                      |                                |
| Web Resources         |                                                                                                                                                                                                                                                                           |                                |
| 1.                    | <a href="https://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf">https://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf</a>                                                                       |                                |
| 2.                    | <a href="https://ucanapplym.s3.ap-south-1.amazonaws.com/RGU/notifications/E_learning/Online_study/PG-SEM-IV-Biosafety%20regulation.pdf">https://ucanapplym.s3.ap-south-1.amazonaws.com/RGU/notifications/E_learning/Online_study/PG-SEM-IV-Biosafety%20regulation.pdf</a> |                                |
| 3.                    | <a href="https://consteril.com/biosafety-levels-difference/">https://consteril.com/biosafety-levels-difference/</a>                                                                                                                                                       |                                |
| 4.                    | <a href="https://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf">https://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf</a>                                                                       |                                |
| 5.                    | <a href="https://www.who.int/publications/i/item/9789240011311">https://www.who.int/publications/i/item/9789240011311</a>                                                                                                                                                 |                                |
| Methods of Evaluation |                                                                                                                                                                                                                                                                           |                                |
| Internal Evaluation   | Continuous Internal Assessment Tests                                                                                                                                                                                                                                      | 25 Marks                       |
|                       | Assignments                                                                                                                                                                                                                                                               |                                |
|                       | Seminars                                                                                                                                                                                                                                                                  |                                |
|                       | Attendance and Class Participitation                                                                                                                                                                                                                                      |                                |
| External Evaluation   | End Semester Examination                                                                                                                                                                                                                                                  | 75 Marks                       |
|                       | Total                                                                                                                                                                                                                                                                     | 100 Marks                      |
| Methods of Assessment |                                                                                                                                                                                                                                                                           |                                |
| Recall (KI)           | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                                                                                                                                |                                |

|                              |                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | S    | S    | S    |      |      |      | S    |      |      |       | S     |       |       |       |
| CO2 |      | S    |      |      | S    |      | S    |      |      |       | S     |       |       |       |
| CO3 | S    | S    | S    |      | S    |      |      |      |      | S     | S     |       |       |       |
| CO4 |      | S    | S    | M    |      |      | S    |      |      | S     | S     |       |       |       |
| CO5 |      |      | S    | S    | S    |      | S    |      |      | S     | S     |       |       |       |

| Subject Code             | Subject Name                                                                                                                                 | Category                              | L        | T        | P        | S        | Credits  | Inst. Hours | Marks     |           |            |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|----------|----------|----------|----------|----------|-------------|-----------|-----------|------------|
|                          |                                                                                                                                              |                                       |          |          |          |          |          |             | CIA       | External  | Total      |
| <b>22MBP GPCC1</b>       | <b>Entrepreneurship in Biobusiness</b>                                                                                                       | <b>Professional Competency Course</b> | <b>Y</b> | <b>-</b> | <b>-</b> | <b>-</b> | <b>2</b> | <b>2</b>    | <b>25</b> | <b>75</b> | <b>100</b> |
| <b>Course Objectives</b> |                                                                                                                                              |                                       |          |          |          |          |          |             |           |           |            |
| CO1                      | Understanding basic concepts in the area of entrepreneurship, the role and importance of entrepreneurship for economic development.          |                                       |          |          |          |          |          |             |           |           |            |
| CO2                      | Developing personal creativity and entrepreneurial initiative, adopting of the key steps in the elaboration of business idea.                |                                       |          |          |          |          |          |             |           |           |            |
| CO3                      | Understanding the stages of the entrepreneurial process and the resources needed for the successful development of entrepreneurial ventures. |                                       |          |          |          |          |          |             |           |           |            |
| CO4                      | Explain the central components of successful business strategies in biotechnology, and                                                       |                                       |          |          |          |          |          |             |           |           |            |

|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                               |                          |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|--------------------------|
|                        | create a business plan.                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                               |                          |
| CO5                    | Acquire knowledge about proposal preparation, funding and face challenges in biobusiness.                                                                                                                                                                                                                                                                                                                                                                                               |                               |                          |
| <b>UNIT</b>            | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>No. of Hours</b>           | <b>Course Objectives</b> |
| I                      | Bio Entrepreneurship - Introduction to bio-business, SWOT analysis of bio-business. Ownership. Development of Entrepreneurship. Stages in entrepreneurial process. Government schemes and funding. Small scale industries - Definition, characteristics, need and rationale.                                                                                                                                                                                                            | 6                             | CO1                      |
| II                     | Entrepreneurship opportunity in agricultural Microbiology - Business opportunity, Essential requirement, marketing, strategies, schemes, challenges and scope. Case study on Plant cell and tissue culture technique, polyhouse culture. Herbal bulk drug production, nutraceuticals, value added herbal products. Bioethanol production using agricultural waste, algal source. Integration of system biology for agricultural applications. Biosensor development in agri management. | 6                             | CO2                      |
| III                    | Entrepreneurship opportunity in industrial biotechnology - Business opportunity, Essential requirement, marketing strategies, schemes, challenges, and scope. Pollution monitoring and Bioremediation for Industrial pollutants. Integrated compost production - microbe enriched compost. Bio pesticide/ insecticide production. Biofertilizers. Single cell protein.                                                                                                                  | 6                             | CO3                      |
| IV                     | Therapeutic and Fermented products - Stem cell production, stem cell bank, production of monoclonal/polyclonal antibodies, secondary metabolite production – antibiotics, probiotic and prebiotics.                                                                                                                                                                                                                                                                                     | 6                             | CO4                      |
| V                      | Project Management, Technology Management and Startup Schemes - Building Biotech business challenges in Indian context - biotech partners (BIRAC, DBT, Incubation centers. etc.), operational biotech parks in India. Indian Company act for Biobusiness - schemes and subsidies. Project proposal preparation, Successful start-ups-case study.                                                                                                                                        | 6                             | CO5                      |
|                        | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 30                            |                          |
| <b>Course Outcomes</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                               |                          |
| <b>Course Outcomes</b> | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                                            |                               |                          |
| CO1                    | Describe and apply several entrepreneurial ideas and business theories in practical framework.                                                                                                                                                                                                                                                                                                                                                                                          | PO1, PO2, PO4, PO5, PO8, PO12 |                          |

|                         |                                                                                                                                                                                                                                                                                     |                                |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| CO2                     | Analyse the business environment in order to identify business opportunities, identify the elements of success of entrepreneurial ventures, evaluate the effectiveness of different entrepreneurial strategies and interpret their own business plan.                               | PO1, PO2, PO4, PO7, PO10, PO11 |
| CO3                     | Express the mass production of microbial inoculants used as Biofertilizers and Bioinsecticides in response with field application and crop response.                                                                                                                                | PO1, PO4, PO5, PO8, PO9, PO11  |
| CO4                     | Analyze the application and commercial production of Monoclonal antibodies, Cytokines. TPH and teaching kits.                                                                                                                                                                       | PO2, PO4, PO8, PO11            |
| CO5                     | Integrate and apply knowledge of the regulation of biotechnology industries, utilize effective team work skills within an effective management team with a common objective, and gain effective team work skills, with an awareness of cultural diversity and social inclusiveness. | PO4, PO5, PO8, PO9, PO12       |
| <b>Text Books</b>       |                                                                                                                                                                                                                                                                                     |                                |
| 1.                      | Shimasaki C. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies- Academic Press. ISBN: 978-0-12-404730-3                                                                                                                                     |                                |
| 2.                      | Acton A. Q. (2021). Biological Pigments - Advances in Research and Application- (Scholarly Editions). Atlanta, Georgia. ISBN: 978-1-481-68574-0                                                                                                                                     |                                |
| 3.                      | Stanbury P. F. and Whitekar. A. Principles of Fermentation Technology, (3 <sup>rd</sup> Edition). Butterworth-Heinemann. ISBN 10: 0080999530                                                                                                                                        |                                |
| 4                       | Anil Kumar (2020). Small Business and Entrepreneurship, Willey Distributions, Dream Tech Press.                                                                                                                                                                                     |                                |
| 5                       | Angi Redy (2015). An Unfinished Agenda. ISBN 139780670087808.                                                                                                                                                                                                                       |                                |
| <b>References Books</b> |                                                                                                                                                                                                                                                                                     |                                |
| 1.                      | Crueger, W, and Crueger. A. (2017). Biotechnology: A Text Book of Industrial Microbiology. (2 <sup>nd</sup> Edition). Medtech. ISBN-10 : 9385998633                                                                                                                                 |                                |
| 2.                      | Teng P. S. (2008). Bioscience Entrepreneurship in Asia. World Scientific Publishing Company. 2008.                                                                                                                                                                                  |                                |
| 3.                      | Agarwal S., Kumari S. and Khan S. (2021). Bioentrepreneurship and Transferring Technology into Product Development. Business Science Reference. ISBN-10 : 1799874125                                                                                                                |                                |
| 4.                      | Krishnamurthy A.G. Dirubai Ambani Against All Odds. McGraw Hills.                                                                                                                                                                                                                   |                                |
| 5.                      | Peter F. Drucker. Innovation and Entrepreneurship (1985).                                                                                                                                                                                                                           |                                |
| <b>Web Resources</b>    |                                                                                                                                                                                                                                                                                     |                                |
| 1.                      | <a href="https://www.profitableventure.com/biotech-business-ideas/">https://www.profitableventure.com/biotech-business-ideas/</a>                                                                                                                                                   |                                |

|                              |                                                                                                                                                             |           |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 2.                           | <a href="https://www.bio-rad.com/webroot/web/pdf/lse/literature/Biobusiness.pdf">https://www.bio-rad.com/webroot/web/pdf/lse/literature/Biobusiness.pdf</a> |           |
| 3.                           | <a href="https://www.nature.com/articles/s41587-021-01110-3">https://www.nature.com/articles/s41587-021-01110-3</a>                                         |           |
| 4.                           | <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3003900/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3003900/</a>                                   |           |
| 5.                           | <a href="https://springhouse.in/government-schemes-every-entrepreneur/">https://springhouse.in/government-schemes-every-entrepreneur/</a>                   |           |
| Methods of Evaluation        |                                                                                                                                                             |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                        | 25 Marks  |
|                              | Assignments                                                                                                                                                 |           |
|                              | Seminars                                                                                                                                                    |           |
|                              |                                                                                                                                                             |           |
|                              | Attendance and Class Participation                                                                                                                          |           |
| External Evaluation          | End Semester Examination                                                                                                                                    | 75 Marks  |
|                              | Total                                                                                                                                                       | 100 Marks |
| Methods of Assessment        |                                                                                                                                                             |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                  |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                              |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                      |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                             |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                                                      |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                                                    |           |

### Mapping with Programme Outcomes

|  |      |      |      |      |      |      |      |      |      |       |       |       |       |       |
|--|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
|  | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|--|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|

|     |   |   |  |   |   |  |   |   |   |   |   |   |  |  |
|-----|---|---|--|---|---|--|---|---|---|---|---|---|--|--|
| CO1 | S | S |  | S | S |  |   | S |   |   |   | S |  |  |
| CO2 | S | S |  | S |   |  | S |   |   | S | S |   |  |  |
| CO3 | S |   |  | S | S |  |   | S | S |   | S |   |  |  |
| CO4 |   | S |  | S |   |  |   | S |   |   | S |   |  |  |
| CO5 |   |   |  | S | S |  |   | S | S |   |   | S |  |  |

**FIRST YEAR  
SEMESTER II**

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                                                                                     | Category       | L | T | P | S | Credits | Inst. Hours | Marks               |                          |       |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---|---|---|---|---------|-------------|---------------------|--------------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                  |                |   |   |   |   |         |             | CIA                 | External                 | Total |
| 22MBPG CT4               | Medical Bacteriology and Mycology                                                                                                                                                                                                                                                                                                                                                                                                | Core Course IV | Y | Y | - | - | 4       | 6           | 25                  | 75                       | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                  |                |   |   |   |   |         |             |                     |                          |       |
| CO1                      | Acquire Knowledge on collection, transportation and processing of various kinds of clinical specimens.                                                                                                                                                                                                                                                                                                                           |                |   |   |   |   |         |             |                     |                          |       |
| CO2                      | Explain morphology, characteristics and pathogenesis of bacteria.                                                                                                                                                                                                                                                                                                                                                                |                |   |   |   |   |         |             |                     |                          |       |
| CO3                      | Discuss various factors leading to pathogenesis of bacteria.                                                                                                                                                                                                                                                                                                                                                                     |                |   |   |   |   |         |             |                     |                          |       |
| CO4                      | Acquire knowledge on antifungal agents and their importance.                                                                                                                                                                                                                                                                                                                                                                     |                |   |   |   |   |         |             |                     |                          |       |
| CO5                      | Describe various diagnostic methods available for fungal disease diagnosis.                                                                                                                                                                                                                                                                                                                                                      |                |   |   |   |   |         |             |                     |                          |       |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                                                                                   |                |   |   |   |   |         |             | <b>No. of Hours</b> | <b>Course Objectives</b> |       |
| I                        | Classification of medically important bacteria, Normal flora of human body, Collection, transport, storage and processing of clinical specimens, Microbiological examination of clinical specimens, antimicrobial susceptibility testing. Handling and maintenance of laboratory animals – Rabbits, guinea pigs and mice.                                                                                                        |                |   |   |   |   |         |             | 20                  | CO1                      |       |
| II                       | Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of <i>Staphylococci</i> , <i>Streptococci</i> , <i>Pneumococci</i> , <i>Neisseriae</i> ., <i>Bacillus</i> , <i>Corynebacteria</i> , <i>Mycobacteria</i> and <i>Clostridium</i> .                                                                                                                     |                |   |   |   |   |         |             | 20                  | CO2                      |       |
| III                      | Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by Enterobacteriaceae members, <i>Yersinia</i> , <i>Pseudomonas</i> , <i>Vibrio</i> , <i>Mycoplasma</i> , <i>Helicobacter</i> , <i>Rickettsiae</i> , <i>Chlamydiae</i> , <i>Bordetella</i> , <i>Francisella</i> ., <i>Spirochaetes</i> - <i>Leptospira</i> , <i>Treponema</i> and <i>Borrelia</i> . Nosocomial, |                |   |   |   |   |         |             | 20                  | CO3                      |       |

|                  |                                                                                                                                                                                                                                                                                                                                                                          |             |     |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----|
|                  | zoonotic and opportunistic infections -prevention and control.                                                                                                                                                                                                                                                                                                           |             |     |
| IV               | Morphology, taxonomy and classification of fungi. Detection and recovery of fungi from clinical specimens. Dermatophytes and agents of superficial mycoses. <i>Trichophyton</i> , <i>Epidermophyton</i> & <i>Microsporum</i> . Yeasts of medical importance – <i>Candida</i> , <i>Cryptococcus</i> . Mycotoxins. Antifungal agents, testing methods and quality control. | 15          | CO4 |
| V                | Dimorphic fungi causing Systemic mycoses, <i>Histoplasma</i> , <i>Coccidioides</i> , <i>Sporothrix</i> , <i>Blastomyces</i> . Fungi causing Eumycotic Mycetoma, Opportunistic fungi- Fungi causing secondary infections in immunocompromised patients. Immunodiagnostic methods in mycology- Recent advancements in diagnosis. Antifungal agents.                        | 15          | CO5 |
|                  | Total                                                                                                                                                                                                                                                                                                                                                                    | 90          |     |
| Course Outcomes  |                                                                                                                                                                                                                                                                                                                                                                          |             |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                             |             |     |
| CO1              | Collect, transport and process of various kinds of clinical specimens.                                                                                                                                                                                                                                                                                                   | PO1,PO5,PO9 |     |
| CO2              | Analyze various bacteria based on morphology and pathogenesis.                                                                                                                                                                                                                                                                                                           | PO1,PO5,PO9 |     |
| CO3              | Discuss various treatment methods for bacterial disease.                                                                                                                                                                                                                                                                                                                 | PO1,PO5,PO9 |     |
| CO4              | Employ various methods detect fungi in clinical samples and apply knowledge on antifungal agents..                                                                                                                                                                                                                                                                       | PO5,PO9     |     |
| CO5              | Apply various immunodiagnostic method to detect fungal infections.                                                                                                                                                                                                                                                                                                       | PO5,PO9     |     |
| Text Books       |                                                                                                                                                                                                                                                                                                                                                                          |             |     |
| 1.               | Kanunga R. (2017). Ananthanarayanan and Panicker’s Text book of Microbiology. (2017).Orient Longman, Hyderabad.                                                                                                                                                                                                                                                          |             |     |
| 2.               | Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18 <sup>th</sup> Edition). Churchill Livingstone, London.                                                                                                                                                                                                                                 |             |     |
| 3.               | Finegold, S. M. (2000) Diagnostic Microbiology, (10 <sup>th</sup> Edition). C.V. Mosby Company, St. Louis.                                                                                                                                                                                                                                                               |             |     |
| 4.               | Alexopoulos C. J., Mims C. W. and Blackwell M. (2007). Introductory Mycology, (4 <sup>th</sup> Edition). Wiley Publishers.                                                                                                                                                                                                                                               |             |     |
| 5.               | Chander J. (2018). Textbook of Medical Mycology. (4 <sup>th</sup> Edition). Jaypee brothers Medical Publishers.                                                                                                                                                                                                                                                          |             |     |
| References Books |                                                                                                                                                                                                                                                                                                                                                                          |             |     |
| 1.               | Salle A. J. (2007). Fundamental Principles of Bacteriology. (4 <sup>th</sup> Edition). Tata McGraw-Hill Publications.                                                                                                                                                                                                                                                    |             |     |
| 2.               | Collee J.C. Duguid J.P. Foraser, A.C, Marimon B.P, (1996). Mackie & McCartney                                                                                                                                                                                                                                                                                            |             |     |



|                              |                                                                                                                                                           |           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|                              | <u>Practical Medical Microbiology</u> . 14 <sup>th</sup> edn, Churchill Livingston.                                                                       |           |
| 3.                           | Cheesbrough M. (2006). <u>District Laboratory Practice in Tropical countries.- Part 22<sup>nd</sup></u> edn.Cambridge University Press.<br>.              |           |
| 4.                           | Topley and Wilson’s. (1998). <u>Principles of Bacteriology</u> .9 <sup>th</sup> edn. Edward Arnold, London.                                               |           |
| 5.                           | Murray P.R., Rosenthal K.S. and Michael A. (2013). <u>Medical Microbiology</u> . Pfaller. 7 <sup>th</sup> edn. Elsevier, Mosby Saunders.                  |           |
| <b>Web Resources</b>         |                                                                                                                                                           |           |
| 1.                           | <a href="http://textbookofbacteriology.net/nd">http://textbookofbacteriology.net/nd</a>                                                                   |           |
| 2.                           | <a href="https://microbiologysociety.org/members-outreach-resources/links.html">https://microbiologysociety.org/members-outreach-resources/links.html</a> |           |
| 3.                           | <a href="https://www.pathelective.com/micro-resources">https://www.pathelective.com/micro-resources</a>                                                   |           |
| 4.                           | <a href="http://mycology.cornell.edu/fteach.html">http://mycology.cornell.edu/fteach.html</a>                                                             |           |
| 5.                           | <a href="https://www.adelaide.edu.au/mycology/">https://www.adelaide.edu.au/mycology/</a>                                                                 |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                           |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                      | 25 Marks  |
|                              | Assignments                                                                                                                                               |           |
|                              | Seminars                                                                                                                                                  |           |
|                              | Attendance and Class Participation                                                                                                                        |           |
| External Evaluation          | End Semester Examination                                                                                                                                  | 75 Marks  |
|                              | Total                                                                                                                                                     | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                                                           |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                            |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                    |           |
| Analyze (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                           |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                                                    |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                                                  |           |

### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | M    |      |      |      | S    |      |      |      | M    |       |       |       |       |       |
| CO2 | M    |      |      |      | S    |      |      |      | M    |       |       |       |       |       |
| CO3 | M    |      |      |      | S    |      |      |      | M    |       |       |       |       |       |
| CO4 |      |      |      |      | S    |      |      |      | M    |       |       |       |       |       |
| CO5 |      |      |      |      | S    |      |      |      | M    |       |       |       |       |       |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                            | Category             | L | T | P | S | Credits | Inst. Hours | Marks |                     |                          |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---|---|---|---|---------|-------------|-------|---------------------|--------------------------|
|                          |                                                                                                                                                                                                                                                                                                                                                                         |                      |   |   |   |   |         |             | CIA   | External            | Total                    |
| 22MBPGCT5                | Medical Virology and Parasitology                                                                                                                                                                                                                                                                                                                                       | Core Course V Theory | Y | Y | - | - | 4       | 6           | 25    | 75                  | 100                      |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                         |                      |   |   |   |   |         |             |       |                     |                          |
| CO1                      | Describe the replication strategy and cultivation methods of viruses.                                                                                                                                                                                                                                                                                                   |                      |   |   |   |   |         |             |       |                     |                          |
| CO2                      | Acquire knowledge about oncogenic virus and human viral infections.                                                                                                                                                                                                                                                                                                     |                      |   |   |   |   |         |             |       |                     |                          |
| CO3                      | Develop diagnostic skills, in the identification of virus infections.                                                                                                                                                                                                                                                                                                   |                      |   |   |   |   |         |             |       |                     |                          |
| CO4                      | Impart knowledge about parasitic infections.                                                                                                                                                                                                                                                                                                                            |                      |   |   |   |   |         |             |       |                     |                          |
| CO5                      | Develop diagnostic skills, in the identification of parasitic infections.                                                                                                                                                                                                                                                                                               |                      |   |   |   |   |         |             |       |                     |                          |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                          |                      |   |   |   |   |         |             |       | <b>No. of Hours</b> | <b>Course Objectives</b> |
| I                        | General properties of viruses - Structure and Classification - viroids, prions, satellite RNAs and virusoids. Cultivation of viruses - embryonated eggs, experimental animals and cell cultures. Purification and Assay of viruses – Physical and Chemical methods (Electron Microscopy, Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end-point). |                      |   |   |   |   |         |             |       | 20                  | CO1                      |
| II                       | Virus Entry, Host Defenses Against Viral Infections, Epidemiology, pathogenic mechanisms, Pathogenesis, laboratory diagnosis, treatment for the following viruses: DNA Viruses- Pox , Herpes , Adeno , Papova and Hepadna , RNA Viruses- Picorna, Orthomyxo, Paramyxo, Rhabdo,                                                                                          |                      |   |   |   |   |         |             |       | 20                  | CO2                      |

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                     |     |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----|
|                 | Rota, HIV and other Hepatitis viruses, Arbo – Dengue virus, Ebola virus, Emerging and reemerging viral infections                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                     |     |
| III             | Bacterial viruses - ΦX 174, M13, MU, T4, lambda, Pi; Structural organization, life cycle and phage production. Lysogenic cycle-typing and application in bacterial genetics. Diagnosis of viral infections –conventional serological and molecular methods. Antiviral agents and viral vaccines.                                                                                                                                                                                                                                                                                                                                                                       | 15                  | CO3 |
| IV              | Introduction to Medical Parasitology – Classification, host-parasite relationships. Epidemiology, life cycle, pathogenic mechanisms, laboratory diagnosis, treatment for the following: Protozoa causing human infections – <i>Entamoeba</i> , Aerobic and Anaerobic amoebae, <i>Giardia</i> , <i>Trichomonas</i> , <i>Balantidium</i> . <i>Toxoplasma</i> , <i>Cryptosporidium</i> , <i>Leishmania</i> , and <i>Trypanasoma</i> .                                                                                                                                                                                                                                     | 15                  | CO4 |
| V               | Classification, life cycle, pathogenicity, laboratory diagnosis and treatment for parasites – Helminthes - Cestodes – <i>Taenia Solium</i> , <i>T. Saginata</i> , <i>T. Echinococcus</i> . Trematodes – <i>Fasciola Hepatica</i> , <i>Fasciolopsis Buski</i> , <i>Paragonimus</i> , <i>Schistosomes</i> . Nematodes - <i>Ascaris</i> , <i>Ankylostoma</i> , <i>Trichuris</i> , <i>Trichinella</i> , <i>Enterobius</i> , <i>Strongyloides</i> and <i>Wuchereria</i> . Other parasites causing infections in immune compromised hosts and AIDS. Cultivation of parasites. Diagnosis of parasitic infections – Serological and molecular diagnosis. Anti-protozoan drugs. | 20                  | CO5 |
|                 | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 90                  |     |
| Course Outcomes |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                     |     |
| Course Outcomes | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |     |
| CO1             | Cultivate viruses by different methods and aid in diagnosis. Perform purification and viral assay.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | PO5, PO7, PO8, PO10 |     |
| CO2             | Investigate the symptoms of viral infections and presumptively identify the viral disease.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | PO5, PO7, PO8, PO10 |     |
| CO3             | Diagnose various viral diseases by different methods.(serological, conventional and molecular)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | PO5, PO7, PO8, PO10 |     |
| CO4             | Educate public about the spread, control and prevention of parasitic diseases.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | PO5, PO7, PO8, PO10 |     |
| CO5             | Identify the protozoans and helminthes present in stool and blood specimens. Perform serological and molecular diagnosis of parasitic infections.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | PO5, PO7, PO8, PO10 |     |
| Text Books      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                     |     |
| 1.              | Kanunga R. (2017). Ananthanarayanan and Panicker’s Text book of Microbiology. (10 <sup>th</sup> Edition). Universities Press (India ) Pvt. Ltd.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                     |     |
| 2.              | Dubey, R.C. and Maheshwari D.K. (2010). A Text Book of Microbiology. S.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |     |

|                        |                                                                                                                                                    |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
|                        | Chand & Co.                                                                                                                                        |
| 3.                     | Rajan S. (2007). Medical Microbiology. MJP publisher.                                                                                              |
| 4.                     | Paniker J. (2006). Text Book of Parasitology. Jay Pee Brothers, New Delhi.                                                                         |
| 5.                     | Arora, D. R. and Arora B. B. (2020). Medical Parasitology. (5 <sup>th</sup> Edition). CBS Publishers & Distributors Pvt. Ltd. New Delhi.           |
| <b>Reference Books</b> |                                                                                                                                                    |
| 1.                     | Carter J. (2001). Virology: Principles and Applications (1 <sup>st</sup> Edition). Wiley Publications.                                             |
| 2..                    | Willey J., Sandman K. and Wood D. Prescott's Microbiology. (11 <sup>th</sup> Edition). McGraw Hill Book.                                           |
| 3.                     | Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19 <sup>th</sup> Edition). Lange Medical Publications, U.S.A. |
| 4.                     | Finegold S.M. (2000). Diagnostic Microbiology. (10 <sup>th</sup> Edition). C.V. Mosby Company, St. Louis.                                          |

| Web Resources         |                                                                                                                                                       |           |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1.                    | <a href="https://en.wikipedia.org/wiki/Virology">https://en.wikipedia.org/wiki/Virology</a>                                                           |           |
| 2.                    | <a href="https://academic.oup.com/femsre/article/30/3/321/546048">https://academic.oup.com/femsre/article/30/3/321/546048</a>                         |           |
| 3.                    | <a href="https://www.sciencedirect.com/science/article/pii/S0042682215000859">https://www.sciencedirect.com/science/article/pii/S0042682215000859</a> |           |
| 4.                    | <a href="https://nptel.ac.in/courses/102/103/102103039/">https://nptel.ac.in/courses/102/103/102103039/</a>                                           |           |
| 5.                    | <a href="https://www.healthline.com/health/viral-diseases#contagiousness">https://www.healthline.com/health/viral-diseases#contagiousness</a>         |           |
| Methods of Evaluation |                                                                                                                                                       |           |
| Internal Evaluation   | Continuous Internal Assessment Tests                                                                                                                  | 25 Marks  |
|                       | Assignments                                                                                                                                           |           |
|                       | Seminars                                                                                                                                              |           |
|                       | Attendance and Class Participation                                                                                                                    |           |
| External Evaluation   | End Semester Examination                                                                                                                              | 75 Marks  |
|                       | Total                                                                                                                                                 | 100 Marks |
| 5.                    | Levanthal R. and Cheadle R. S. (2012). Medical Parasitology. (6 <sup>th</sup> Edition). S.A. Davies Co. Philadelphia.                                 |           |

|                              |                                                                                |
|------------------------------|--------------------------------------------------------------------------------|
| <b>Methods of Assessment</b> |                                                                                |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                     |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application                  | Suggest idea/concept with examples, Suggest formulae, Solve problems,          |

|               |                                                                                                                 |
|---------------|-----------------------------------------------------------------------------------------------------------------|
| (K3)          | Observe, Explain                                                                                                |
| Analyses (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)   | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

### Mapping with Programme Outcomes

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| CO1 |     |     |     |     | M   |     | L   | L   |     | M    |      |      |      |      |
| CO2 |     |     |     |     | M   |     | L   | L   |     | M    |      |      |      |      |
| CO3 |     |     |     |     | M   |     | L   | L   |     | M    |      |      |      |      |
| CO4 |     |     |     |     | M   |     | L   | L   |     | M    |      |      |      |      |
| CO5 |     |     |     |     | M   |     | L   | L   |     | M    |      |      |      |      |

| Subject Code             | Subject Name                                                                            | Category                      | L | T | P | S | Credits | Inst. Hours | Marks               |                          |           |
|--------------------------|-----------------------------------------------------------------------------------------|-------------------------------|---|---|---|---|---------|-------------|---------------------|--------------------------|-----------|
|                          |                                                                                         |                               |   |   |   |   |         |             | CIA                 | Externa<br>l             | Tota<br>l |
| 22MBPGCP2                | Practical II - Medical Microbiology                                                     | Core Course VI-Practical I II | - | - | Y | - | 4       | 6           | 40                  | 60                       | 100       |
| <b>Course Objectives</b> |                                                                                         |                               |   |   |   |   |         |             |                     |                          |           |
| CO1                      | Develop skills in the diagnosis of bacterial infections and antimicrobial sensitivity.  |                               |   |   |   |   |         |             |                     |                          |           |
| CO2                      | Impart knowledge on fungal infections and its diagnosis.                                |                               |   |   |   |   |         |             |                     |                          |           |
| CO3                      | Cultivation, identification and assay of viruses for diagnostics and vaccine production |                               |   |   |   |   |         |             |                     |                          |           |
| CO4                      | Diagnose parasitic infections.                                                          |                               |   |   |   |   |         |             |                     |                          |           |
| CO5                      | Identification of medically important vectors.                                          |                               |   |   |   |   |         |             |                     |                          |           |
| <b>UNIT</b>              | <b>Details</b>                                                                          |                               |   |   |   |   |         |             | <b>No. of Hours</b> | <b>Course Objectives</b> |           |
| I                        | Staining of clinical specimens - Wet mount, Differential and Special staining methods.  |                               |   |   |   |   |         |             | 20                  | CO1                      |           |

|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |               |     |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----|
|                        | Isolation and identification of bacterial pathogens from clinical specimens - cultivation in basal, differential, enriched, selective and special media – Biochemical identification tests.<br>Enumeration of bacteria in urine to detect significant bacteriuria.<br>Antimicrobial sensitivity testing - Kirby Bauer method and Stokes method.<br>Minimum inhibitory concentration (MIC) test.<br>Minimum bactericidal concentration (MBC) test.                   |               |     |
| II                     | Identification and Classification of common fungi.<br>Examination of different fungi by Lactophenol cotton blue staining.<br>Examination of different fungi by KOH staining.<br>Cultivation of fungi and their identification - <i>Mucor</i> , <i>Rhizopus</i> , <i>Aspergillus</i> , <i>Penicillium</i> .<br>Microscopic observation of different asexual fungal spores.<br>Microscopic observation of fungal fruiting bodies.<br>Identification of Dermatophytes. | 20            | CO2 |
| III                    | Isolation and characterization of bacteriophage from natural sources by phage titration.<br>Cultivation of viruses –Egg Inoculation methods.<br>Diagnosis of Viral Infections –ELISA –HIA.<br>Spotters of viral inclusions and CPE-stained smears.                                                                                                                                                                                                                  | 20            | CO3 |
| IV                     | Examination of parasites in clinical specimens - Ova/cysts in faeces.<br>Concentration: methods – Flootation methods-simple Saturated salt solution method – Zinc sulphate methods - Sedimentation methods- Formal ether method.<br>Blood smear examination for malarial parasites.<br>Thin smear by Leishman's stain – Thick smear by J.B. stain.                                                                                                                  | 15            | CO4 |
| V                      | Identification of common arthropods of medical importance - spotters of <i>Anopheles</i> , <i>Glossina</i> , <i>Phlebotomus</i> , <i>Aedes</i> , Ticks and mites.                                                                                                                                                                                                                                                                                                   | 15            | CO5 |
|                        | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 90            |     |
| <b>Course Outcomes</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |               |     |
| <b>Course Outcomes</b> | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                        |               |     |
| CO1                    | Collection of different clinical samples, transport, culture and examination.                                                                                                                                                                                                                                                                                                                                                                                       | PO7, PO8, PO9 |     |

|                              |                                                                                                                                                                                                                                                                                                                         |                     |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| CO2                          | Identify medically important fungus from the clinical samples.                                                                                                                                                                                                                                                          | PO7, PO8, PO9       |
| CO3                          | Perform and Interpret serological tests for viral diseases.                                                                                                                                                                                                                                                             | PO7, PO8, PO9, PO10 |
| CO4                          | Exam and identify ova and cyst in samples.                                                                                                                                                                                                                                                                              | PO7, PO8, PO9, PO10 |
| CO5                          | Collection and identification of arthropod vectors.                                                                                                                                                                                                                                                                     | PO7, PO8, PO9       |
| <b>Text Books</b>            |                                                                                                                                                                                                                                                                                                                         |                     |
| 1.                           | Cullimore D. R. (2010). Practical Atlas for Bacterial Identification, 2 <sup>nd</sup> Edn. Publisher-Taylor and Francis.                                                                                                                                                                                                |                     |
| 2.                           | Abbott A.C. (2010). The Principles of Bacteriology. Nabu Press.                                                                                                                                                                                                                                                         |                     |
| 3.                           | Parija S. C. (2012). Textbook of Practical Microbiology. Ahuja Publishing House.                                                                                                                                                                                                                                        |                     |
| 4.                           | Cappuccino, J. and Sherman, N. (2002) Microbiology: A Laboratory Manual, (6 <sup>th</sup> Edition). Pearson Education, Publication, New Delhi.                                                                                                                                                                          |                     |
| 5.                           | Morag C. and Timbury M.C. (1994). Medical Virology. 4 <sup>th</sup> edn. Blackwell Scientific Publishers.                                                                                                                                                                                                               |                     |
| <b>References Books</b>      |                                                                                                                                                                                                                                                                                                                         |                     |
| 1.                           | Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14 <sup>th</sup> Edition). Elsevier, New Delhi.                                                                                                                                                      |                     |
| 2.                           | Chart H. (2018). Practical Laboratory Bacteriology. CRC Press.                                                                                                                                                                                                                                                          |                     |
| 3.                           | Moore V. A. (2017). Laboratory Directions for Beginners in Bacteriology. Triste Publishing Ltd.                                                                                                                                                                                                                         |                     |
| 4.                           | .Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.- Part 22 <sup>nd</sup> Edition. Cambridge University Press.                                                                                                                                                                                 |                     |
| 5.                           | Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7 <sup>th</sup> Edition. Elsevier, Mosby Saunders                                                                                                                                                                                     |                     |
| <b>Web Resources</b>         |                                                                                                                                                                                                                                                                                                                         |                     |
| 1.                           | <a href="http://textbookofbacteriology.net/">http://textbookofbacteriology.net/</a>                                                                                                                                                                                                                                     |                     |
| 2.                           | <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7173454/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7173454/</a>                                                                                                                                                                                               |                     |
| 3.                           | <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3768729/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3768729/</a>                                                                                                                                                                                               |                     |
| 4.                           | <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/</a>                                                                                                                                                                                                 |                     |
| 5.                           | <a href="https://www.intechopen.com/books/current-issues-in-molecular-virology-viral-genetics-and-biotechnological-applications/vaccines-and-antiviral-agents">https://www.intechopen.com/books/current-issues-in-molecular-virology-viral-genetics-and-biotechnological-applications/vaccines-and-antiviral-agents</a> |                     |
| <b>Methods of Evaluation</b> |                                                                                                                                                                                                                                                                                                                         |                     |

|                              |                                                                                                                 |           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------|
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                            | 25 Marks  |
|                              | Assignments                                                                                                     |           |
|                              | Seminars                                                                                                        |           |
|                              | Attendance and Class Participation                                                                              |           |
| External Evaluation          | End Semester Examination                                                                                        | 75 Marks  |
|                              | Total                                                                                                           | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                 |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |           |

### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 |      |      |      |      |      |      | M    | M    | M    |       |       |       |       |       |
| CO2 |      |      |      |      |      |      | M    | M    | M    |       |       |       |       |       |
| CO3 |      |      |      |      |      |      | M    | M    | L    | L     |       |       |       |       |
| CO4 |      |      |      |      |      |      | M    | M    | M    | L     |       |       |       |       |
| CO5 |      |      |      |      |      |      | M    | M    | M    |       |       |       |       |       |

| Subject Code | Subject Name | Category            | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------|--------------|---------------------|---|---|---|---|---------|-------------|-------|----------|-------|
|              |              |                     |   |   |   |   |         |             | CIA   | External | Total |
| 22MBP GE3A   | Epidemiology | Elective Course III | Y | Y | - | - | 3       | 4           | 25    | 75       | 100   |



|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |            |  |  |  |  |                     |                          |  |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|--|--|--|--|---------------------|--------------------------|--|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | (Choice 1) |  |  |  |  |                     |                          |  |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |            |  |  |  |  |                     |                          |  |
| CO1                      | Describe the role of epidemiology in public health.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |            |  |  |  |  |                     |                          |  |
| CO2                      | Explain about epidemiology tools and disease surveillance methods.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |            |  |  |  |  |                     |                          |  |
| CO3                      | Analyze various communicable and non-communicable diseases in India.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |            |  |  |  |  |                     |                          |  |
| CO4                      | Discuss on mechanism of antimicrobial resistance.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |            |  |  |  |  |                     |                          |  |
| CO5                      | Outline on National health programmes that have been designed to address the issues.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |            |  |  |  |  |                     |                          |  |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |            |  |  |  |  | <b>No. of Hours</b> | <b>Course Objectives</b> |  |
| I                        | Fundamentals of epidemiology - Definitions of epidemiology – Epidemiology of infectious diseases in Public Health. Natural history of disease - Historical aspects of epidemiology. Common risk factors - Epidemiologic Triad - Agent factors, host factors and environmental factors. Transmission basics - Chain of infection, portal of entry. Modes of transmission - Direct and indirect. Stages of infectious diseases. Agents and vectors of communicable diseases of public health importance and dynamics of disease transmission. Epidemiology of Zoonosis - Factors, routes of transmission of bacterial, viral, parasitic and fungal zoonotic agents. Control of zoonosis.                                                              |            |  |  |  |  | 12                  | CO1                      |  |
| II                       | Tools of Epidemiology - Measures of Disease - Prevalence, incidence. Index case. Risk rates. Descriptive Epidemiology - Cohort studies, measuring infectivity, survey methodology including census procedures. Surveillance strategies - Disease surveillance, geographical indication system, outbreak investigation in public health and contact investigation.                                                                                                                                                                                                                                                                                                                                                                                   |            |  |  |  |  | 12                  | CO2                      |  |
| III                      | Epidemiological aspects of diseases of national importance - Background to communicable and non-communicable diseases. Vector borne diseases in India. Diarrhoeal diseases. Zoonoses. Viral haemorrhagic fevers. Mycobacterial infections. Sexually transmitted diseases. Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS). Emerging disease threats - Severe Acute Respiratory Syndrome (SARS), Covid-19, Ebola, MDR-TB, Malaria, Mucor mycosis, Avian flu. Dengue, Swine Flu, Chikungunya. Epidemiology, prevention, and control of non-communicable diseases - Asthma, Coronary heart disease, Malignancy, diabetes mellitus, respiratory diseases, eye diseases, Dental disorders. Emerging and Re-emerging Diseases. |            |  |  |  |  | 12                  | CO3                      |  |
| IV                       | Mechanisms of Antimicrobial resistance - Multidrug Efflux pumps, Extended Spectrum $\beta$ -lactamases (ESBL). Hospital acquired infections - Factors, infection sites, mechanisms, Role of Multidrug resistant pathogens. Role of <i>Pseudomonas</i> ,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |            |  |  |  |  | 12                  | CO4                      |  |

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |               |     |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----|
|                         | <i>Acinetobacter</i> , <i>Clostridium difficile</i> , HBV, HCV, Rotavirus, <i>Cryptosporidium</i> and <i>Aspergillus</i> in Nosocomial infections. Prevention and management of nosocomial infections.                                                                                                                                                                                                                                                                                                                                                    |               |     |
| V                       | National Programmes related to Communicable and Non-Communicable diseases - National Malaria Eradication Programme, Revised National Tuberculosis Control Programme, Vector Borne Disease Control Programme, National AIDS Control Programme, National Cancer Control Programme and National Diabetes Control Programme. Biochemical and immunological tools in epidemiology - Biotyping, Serotyping, Phage typing, FAME (Fatty acid methyl ester analysis), Curie Point PyMS (Pyrolysis Mass spectrometry), Protein profiling, Molecular typing methods. | 12            | CO5 |
|                         | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 60            |     |
| <b>Course Outcomes</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |               |     |
| <b>Course Outcomes</b>  | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |               |     |
| CO1                     | Apply the knowledge acquired on concepts of epidemiology to clinical and public health environment.                                                                                                                                                                                                                                                                                                                                                                                                                                                       | PO1           |     |
| CO2                     | Plan various strategies to trace the epidemiology.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | PO4, PO5, PO6 |     |
| CO3                     | Plan the control of communicable and non-communicable diseases.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | PO1, PO5,     |     |
| CO4                     | Analyze the implications of drug resistance in the society and design the control of antimicrobial resistance and its management.                                                                                                                                                                                                                                                                                                                                                                                                                         | PO5,          |     |
| CO5                     | Employ National control programs related to Communicable and Non-Communicable diseases with the public.                                                                                                                                                                                                                                                                                                                                                                                                                                                   | PO4, PO5,     |     |
| <b>Text Books</b>       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |               |     |
| 1.                      | Dicker R., Coronado F., Koo. D. and Parrish. R. G. (2012). Principles of Epidemiology in Public Health Practice., (3 <sup>rd</sup> Edition). CDC.                                                                                                                                                                                                                                                                                                                                                                                                         |               |     |
| 2.                      | Gerstman B. (2013). Epidemiology Kept Simple: An Introduction to Classic and Modern Epidemiology. (3 <sup>rd</sup> Edition). Wiley Blackwell.                                                                                                                                                                                                                                                                                                                                                                                                             |               |     |
| 3.                      | Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18 <sup>th</sup> Edition). Churchill Livingstone, London.                                                                                                                                                                                                                                                                                                                                                                                                                  |               |     |
| 4.                      | Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19 <sup>th</sup> Edition). Lange Medical Publications, U.S.A.                                                                                                                                                                                                                                                                                                                                                                                                        |               |     |
| 5.                      | Dimmok N. J. and Primrose S. B. (1994). <u>Introduction to Modern Virology</u> .5 <sup>th</sup> edn. Blackwell Scientific Publishers.                                                                                                                                                                                                                                                                                                                                                                                                                     |               |     |
| <b>References Books</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |               |     |
| 1.                      | Bhopal R. S. (2016).Concepts of Epidemiology - An Integrated Introduction to the Ideas, Theories, Principles and Methods of Epidemiology. (3 <sup>rd</sup> Edition). Oxford University Press, New York.                                                                                                                                                                                                                                                                                                                                                   |               |     |

|    |                                                                                                                                                     |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| 2. | Celentano D. D. and Szklo M. (2018). Gordis Epidemiology. (6 <sup>th</sup> Edition). Elseiver, USA.                                                 |
| 3. | Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2 <sup>nd</sup> Edition). Cambridge University Press.         |
| 4. | Ryan K. J. and Ray C. G. (2004). Sherris Medical Microbiology. (4 <sup>th</sup> Edition), McGraw Hill, New York.                                    |
| 5. | Topley W.W. C., Wilson, G. S., Parker M. T. and Collier L. H. (1998). Principles of Bacteriology. (9 <sup>th</sup> Edition). Edward Arnold, London. |

#### Web Resources

|    |                                                                                                                                                                                                     |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | <a href="https://www.scielo.br/j/rbca/a/mjDFGTtfWtBm786ZmR9TG9d/?lang=en">https://www.scielo.br/j/rbca/a/mjDFGTtfWtBm786ZmR9TG9d/?lang=en</a>                                                       |
| 2. | <a href="https://hal.archives-ouvertes.fr/hal-00902711/document">https://hal.archives-ouvertes.fr/hal-00902711/document</a>                                                                         |
| 3. | <a href="https://www.who.int/csr/resources/publications/whocdscsreph200212.pdf">https://www.who.int/csr/resources/publications/whocdscsreph200212.pdf</a>                                           |
| 4. | <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7187955/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7187955/</a>                                                                           |
| 5. | <a href="https://www.who.int/diseasecontrol_emergencies/publications/idhe_2009_london_outbreaks.pdf">https://www.who.int/diseasecontrol_emergencies/publications/idhe_2009_london_outbreaks.pdf</a> |

#### Methods of Evaluation

|                     |                                      |           |
|---------------------|--------------------------------------|-----------|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks  |
|                     | Assignments                          |           |
|                     | Seminars                             |           |
|                     | Attendance and Class Participation   |           |
| External Evaluation | End Semester Examination             | 75 Marks  |
|                     | Total                                | 100 Marks |

#### Methods of Assessment

|                              |                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |
| Analyze (K4)                 | Problem-solving questions, finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

#### Mapping with Program Outcomes

|  |     |     |     |     |     |     |     |     |     |       |       |       |       |       |
|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-------|-------|-------|
|  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-------|-------|-------|

|     |   |  |  |   |   |   |  |  |  |  |  |  |  |  |
|-----|---|--|--|---|---|---|--|--|--|--|--|--|--|--|
| CO1 | M |  |  |   |   |   |  |  |  |  |  |  |  |  |
| CO2 |   |  |  | L | L | S |  |  |  |  |  |  |  |  |
| CO3 | M |  |  |   | S |   |  |  |  |  |  |  |  |  |
| CO4 |   |  |  |   | S |   |  |  |  |  |  |  |  |  |
| CO5 |   |  |  | S | S |   |  |  |  |  |  |  |  |  |

| Subject Code             | Subject Name                                                                                                                                                                                                   | Category                        | L | T | P | S | Credits | Inst. Hours | Marks               |                          |       |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---|---|---|---|---------|-------------|---------------------|--------------------------|-------|
|                          |                                                                                                                                                                                                                |                                 |   |   |   |   |         |             | CIA                 | External                 | Total |
| 22MBPG E3B               | Clinical and Diagnostic Microbiology                                                                                                                                                                           | Elective Course III ( Choice 2) | Y | Y | - | - | 3       | 4           | 25                  | 75                       | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                |                                 |   |   |   |   |         |             |                     |                          |       |
| CO1                      | Describe appropriate safety protocol and laboratory techniques for handling specimens and biomedical waste management.                                                                                         |                                 |   |   |   |   |         |             |                     |                          |       |
| CO2                      | Develop working knowledge of techniques used to identify infectious agents in the clinical microbiology lab.                                                                                                   |                                 |   |   |   |   |         |             |                     |                          |       |
| CO3                      | Elucidate various diagnostic procedures in microbiology.                                                                                                                                                       |                                 |   |   |   |   |         |             |                     |                          |       |
| CO4                      | Acquire knowledge on different methods employed to check antibiotic sensitivity.                                                                                                                               |                                 |   |   |   |   |         |             |                     |                          |       |
| CO5                      | Gain knowledge on hospital acquired infections and their control measures.                                                                                                                                     |                                 |   |   |   |   |         |             |                     |                          |       |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                 |                                 |   |   |   |   |         |             | <b>No. of Hours</b> | <b>Course Objectives</b> |       |
| I                        | Microbiology Laboratory Safety Practices -General Safety Guidelines, Handling of Biological Hazards, Infectious health care waste disposal - Biomedical waste management, Emerging and Re-emerging infections. |                                 |   |   |   |   |         |             | 12                  | CO1                      |       |
| II                       | Diagnostic procedures - General concept of Clinical specimen collection, transport, storage and general processing in Microbiology laboratory - Specimen acceptance and rejection criteria.                    |                                 |   |   |   |   |         |             | 12                  | CO2                      |       |

|                  |                                                                                                                                                                                                                           |                     |     |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----|
| III              | Diagnosis of microbial diseases - Clinical, differential, Microbiological, immunological and molecular diagnosis of microbial diseases. Modern and novel microbial diagnostic methods. Automation in Microbial diagnosis. | 12                  | CO3 |
| IV               | Antibiotic sensitivity tests - Disc diffusion - Stokes and Kirby Bauer methods, E test - Dilution - Agar dilution & broth dilution - MBC/MIC - Quality control for antibiotics and standard strains.                      | 12                  | CO4 |
| V                | Nosocomial infections – common types, sources, reservoir and mode of transmission, pathogenesis and control measures. Hospital Infection Control Committee (HICC) – Functions.                                            | 12                  | CO5 |
|                  | Total                                                                                                                                                                                                                     | 60                  |     |
| Course Outcomes  |                                                                                                                                                                                                                           |                     |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                                              |                     |     |
| CO1              | Apply Laboratory safety procedures and hospital waste disposal strategies.                                                                                                                                                | PO5, PO6, PO7       |     |
| CO2              | Collect various clinical specimens, handle, preserve and process safely.                                                                                                                                                  | PO6, PO7            |     |
| CO3              | Identify the causative agents of diseases by conventional and molecular methods following standard protocols.                                                                                                             | PO6, PO7, PO9, PO11 |     |
| CO4              | Assess the antimicrobial susceptibility pattern of pathogens.                                                                                                                                                             | PO7, PO9            |     |
| CO5              | Trace the sources of nosocomial infection and recommend control measures.                                                                                                                                                 | PO5, PO7            |     |
| TEXT BOOKS       |                                                                                                                                                                                                                           |                     |     |
| 1.               | Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14 <sup>th</sup> Edition). Elsevier, New Delhi. ISBN-10:0443047219 / ISBN-13-978-0443047213.           |                     |     |
| 2.               | Tille P. M. (2021). Bailey and Scott’s Diagnostic Microbiology. (15 <sup>th</sup> Edition). Elsevier. ISBN:9780323681056.                                                                                                 |                     |     |
| 3.               | Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19 <sup>th</sup> Edition). Lange Medical Publications, U.S.A.                                                                        |                     |     |
| 4.               | Mukherjee K.L. (2000). Medical Laboratory Technology.Vol. 1-3. (2 <sup>nd</sup> Edition). Tata McGraw-Hill Education. ISBN-10:0074632604.                                                                                 |                     |     |
| 5.               | Sood R. (2009). Medical Laboratory Technology – Methods and Interpretations. (6 <sup>th</sup> Edition). Jaypee Brothers Medical Publishers (P) Ltd. New Delhi. ISBN:9788184484496.                                        |                     |     |
| References Books |                                                                                                                                                                                                                           |                     |     |

|                              |                                                                                                                                                                                                                                               |           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1.                           | Murray P. R., Baron E. J., Jorgenson J. H., Pfaller M. A. and Yolken R.H. (2003). Manual of Clinical Microbiology. (8 <sup>th</sup> Edition). American Society for Microbiology, Washington, DC. ISBN:1-555810255-4.                          |           |
| 2.                           | Bennett J. E., Dolin R. and Blaser M. J. (2019). Principles and Practice of Infectious Diseases. (9 <sup>th</sup> Edition). Elsevier. EBook ISBN:9780323550277. Hardcover ISBN:9780323482554.                                                 |           |
| 3.                           | Ridgway G. L., Stokes E. J. and Wren M. W. D. (1987). Clinical Microbiology 7 <sup>th</sup> Edition. Hodder Arnold Publication. ISBN-10:0340554231 / ISBN-13:9780340554234.                                                                   |           |
| 4.                           | Koneman E.W., Allen S. D., Schreckenber P. C. and Winn W. C. (2020). Koneman’s Color Atlas and Textbook of Diagnostic Microbiology. (7 <sup>th</sup> Edition). Jones & Bartlett Learning. ISBN:1284322378 9781284322378.                      |           |
| 5.                           | Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2 <sup>nd</sup> Edition). Cambridge University Press. ISBN-13:978-0-521-67631-1 / ISBN-10:0-521-67631-2.                                                |           |
| <b>Web Resources</b>         |                                                                                                                                                                                                                                               |           |
| 1.                           | <a href="https://www.ncbi.nlm.nih.gov/books/NBK20370/">https://www.ncbi.nlm.nih.gov/books/NBK20370/</a>                                                                                                                                       |           |
| 2.                           | <a href="https://www.msmanuals.com/en-in/home/infections/diagnosis-of-infectious3disease/diagnosis-of-infectious-disease">https://www.msmanuals.com/en-in/home/infections/diagnosis-of-infectious3disease/diagnosis-of-infectious-disease</a> |           |
| 3.                           | <a href="https://journals.asm.org/doi/10.1128/JCM.02592-20">https://journals.asm.org/doi/10.1128/JCM.02592-20</a>                                                                                                                             |           |
| 4.                           | <a href="https://www.sciencedirect.com/science/article/pii/S2221169116309509">https://www.sciencedirect.com/science/article/pii/S2221169116309509</a>                                                                                         |           |
| 5.                           | <a href="http://www.textbookofbacteriology.net/normalflora_3.html">http://www.textbookofbacteriology.net/normalflora_3.html</a>                                                                                                               |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                                                                                                               |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                                                                                          | 25 Marks  |
|                              | Assignments                                                                                                                                                                                                                                   |           |
|                              | Seminars                                                                                                                                                                                                                                      |           |
|                              | Attendance and Class Participation                                                                                                                                                                                                            |           |
| External Evaluation          | End Semester Examination                                                                                                                                                                                                                      | 75 Marks  |
|                              | Total                                                                                                                                                                                                                                         | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                                                                                                                                               |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                                                                                                    |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                                                                                                |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                                                                                                        |           |
| Analyze (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                                                                                                               |           |

|               |                                                                                          |
|---------------|------------------------------------------------------------------------------------------|
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons                   |
| Create (K6)   | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

### Mapping with Programme Outcomes

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-------|-------|-------|
| CO1 |     |     |     |     | S   | M   | M   |     |     |       |       |       |       |       |
| CO2 |     |     |     |     |     | M   | S   |     |     |       |       |       |       |       |
| CO3 |     |     |     |     |     | M   | S   |     | M   |       | S     |       |       |       |
| CO4 |     |     |     |     |     |     | S   |     | M   |       |       |       |       |       |
| CO5 |     |     |     |     | S   |     | M   |     |     |       |       |       |       |       |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                             | Category                       | L | T | P | S | Credits | Inst. Hours | Marks |                     |                          |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|---|---|---|---|---------|-------------|-------|---------------------|--------------------------|
|                          |                                                                                                                                                                                                                                                                                          |                                |   |   |   |   |         |             | CIA   | External            | Total                    |
| 22MBPG E3C               | Bioremediation                                                                                                                                                                                                                                                                           | Elective Course III (Choice 3) | Y | Y | - | - | 3       | 4           | 25    | 75                  | 100                      |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                          |                                |   |   |   |   |         |             |       |                     |                          |
| <b>CO1</b>               | Describe the nature and importance of bioremediation and use in real world applications.                                                                                                                                                                                                 |                                |   |   |   |   |         |             |       |                     |                          |
| <b>CO2</b>               | Describe the typical composition of waste water and application of efficient technologies for water treatment.                                                                                                                                                                           |                                |   |   |   |   |         |             |       |                     |                          |
| <b>CO3</b>               | Explain the fundamentals of treatment technologies and the considerations for its design and implementation in treatment plants.                                                                                                                                                         |                                |   |   |   |   |         |             |       |                     |                          |
| <b>CO4</b>               | Explain the potential of microbes in ore extraction and acquaint students with methods of reducing health risks caused by xenobiotics.                                                                                                                                                   |                                |   |   |   |   |         |             |       |                     |                          |
| <b>CO5</b>               | Familiarize the role of plants and their associated microbes in remediation and management of environmental pollution.                                                                                                                                                                   |                                |   |   |   |   |         |             |       |                     |                          |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                           |                                |   |   |   |   |         |             |       | <b>No. of Hours</b> | <b>Course Objectives</b> |
| I                        | Bioremediation - process and organisms involved. Bioaugmentation - Ex-situ and in-situ processes; Intrinsic and engineered bioremediation. Major pollutants and associated risks; organic pollutant degradation. Microbial aspects and metabolic aspects. Factors affecting the process. |                                |   |   |   |   |         |             |       | 12                  | CO1                      |

|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                     |                         |     |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----|
|                        | Recent developments and significance.                                                                                                                                                                                                                                                                                                                                                                                               |                         |     |
| II                     | Microbes involved in aerobic and anaerobic processes in nature. Water treatment - BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal. Secondary waste water treatments - use of membrane bioreactor. Aquaculture effluent treatment. Aerobic sludge and landfill leachate process. Aerobic digestion.                                                                                                 | 12                      | CO2 |
| III                    | Composting of solid wastes, anaerobic digestion - methane production and important factors involved, Pros and cons of anaerobic process, sulphur, iron and nitrate reduction, hydrocarbon degradation, degradation of nitroaromatic compounds. Bioremediation of dyes, bioremediation in paper and pulp industries. Aerobic and anaerobic digesters – design. Various types of digester for bioremediation of industrial effluents. | 12                      | CO3 |
| IV                     | Microbial leaching of ores - process, microorganisms involved and metal recovery with special reference to copper and iron. Biotransformation of heavy metals and xenobiotics. Petroleum biodegradation - reductive and oxidative. Dechlorination. Biodegradable of plastics and super bug.                                                                                                                                         | 12                      | CO4 |
| V                      | Phytoremediation of heavy metals in soil - Basic principles of phytoremediation - Uptake and transport, Accumulation and sequestration. Phytoextraction. Phytodegradation. Phytovolatilization. Rhizodegradation. Phytostabilization – Organic and synthetic amendments in multi metal contaminated mine sites. Role of Arbuscular mycorrhizal fungi and plant growth promoting rhizobacteria in phytoremediation.                  | 12                      | CO5 |
|                        | Total                                                                                                                                                                                                                                                                                                                                                                                                                               | 60                      |     |
| <b>Course Outcomes</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                     |                         |     |
| <b>Course Outcomes</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                     |                         |     |
| CO1                    | Differentiate Ex-situ bioremediation and In-situ bioremediation.<br>Assess the roles of organisms in bioremediation.                                                                                                                                                                                                                                                                                                                | PO1, PO2, PO4, PO5      |     |
| CO2                    | Distinguish microbial processes necessary for the design and optimization of biological processing unit operations.                                                                                                                                                                                                                                                                                                                 | PO1, PO4, PO5, PO11     |     |
| CO3                    | Identify, formulate and design engineered solutions to environmental problems.                                                                                                                                                                                                                                                                                                                                                      | PO5, PO7, PO8, PO11     |     |
| CO4                    | Explore microbes in degradation of toxic wastes and playing role on biological mechanisms.                                                                                                                                                                                                                                                                                                                                          | PO5, PO6, PO7, PO8, PO9 |     |
| CO5                    | Establish the mechanisms of Arbuscular mycorrhizal fungi                                                                                                                                                                                                                                                                                                                                                                            | PO1, PO5, PO6,          |     |



|                              |                                                                                                                                                                                                                                              |           |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|                              | and Plant growth promoting <i>Rhizobacteria</i> in phytoremediation.                                                                                                                                                                         | PO7, PO8  |
| <b>Text Books</b>            |                                                                                                                                                                                                                                              |           |
| 1.                           | Bhatia H.S. (2018). A Text book on Environmental Pollution and Control. (2 <sup>nd</sup> Edition). Galgotia Publications.                                                                                                                    |           |
| 2.                           | Chatterjee A. K. (2011). Introduction to Environmental Biotechnology. (3 <sup>rd</sup> Edition). Printice-Hall, India.                                                                                                                       |           |
| 3.                           | Pichtel, J. (2014). Waste Management Practices: Municipal, Hazardous, and Industrial, 2 <sup>nd</sup> edition, CRC Press.                                                                                                                    |           |
| 4.                           | Liu, D.H.F and Liptak, B.G (2005). Hazardous Wastes and Solid Wastes, Lewis Publishers.                                                                                                                                                      |           |
| 5.                           | Rajendran, P. & Gunasekaran, P. (2006). Microbial Bioremediation. 1 <sup>st</sup> edition. MJP Publishers                                                                                                                                    |           |
| <b>References Books</b>      |                                                                                                                                                                                                                                              |           |
| 1.                           | Sangeetha J., Thangadurai D., David M. and Abdullah M.A. (2016). Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. (1 <sup>st</sup> Edition). Apple Academic Press. |           |
| 2.                           | Singh A. and Ward O. P. (2004). Biodegradation and Bioremediation. Soil Biology. Springer.                                                                                                                                                   |           |
| 3.                           | Singh A., Kuhad R. C., and Ward O. P. (2009). Advances in Applied Bioremediation (1 <sup>st</sup> Edition). Springer-Verlag Berlin Heidelberg, Germany.                                                                                      |           |
| 4.                           | Atlas, R.M & Bartha, R. (2000). Microbial Ecology. Addison Wesley Longman Inc.                                                                                                                                                               |           |
| 5.                           | Rathoure, A.K. (Ed.). (2017). Bioremediation: Current Research and Applications. 1 <sup>st</sup> edition. I.K. International Publishing House Pvt. Ltd.                                                                                      |           |
| <b>Web Resources</b>         |                                                                                                                                                                                                                                              |           |
| 1.                           | Bioremediation- Objective, Principle, Categories, Types, Methods, Applications (microbenotes.com)                                                                                                                                            |           |
| 2.                           | <a href="https://agris.fao.org/agris-search">https://agris.fao.org/agris-search</a>                                                                                                                                                          |           |
| 3.                           | <a href="https://www.sciencedirect.com/topics/earth-and-planetary-sciences/bioremediation">https://www.sciencedirect.com/topics/earth-and-planetary-sciences/bioremediation</a>                                                              |           |
| 4.                           | <a href="https://www.intechopen.com/chapters/70661">https://www.intechopen.com/chapters/70661</a>                                                                                                                                            |           |
| 5.                           | <a href="https://microbiologysociety.org/blog/bioremediation-the-pollution-solution.html">https://microbiologysociety.org/blog/bioremediation-the-pollution-solution.html</a>                                                                |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                                                                                                              |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                                                                                         | 25 Marks  |
|                              | Assignments                                                                                                                                                                                                                                  |           |
|                              | Seminars                                                                                                                                                                                                                                     |           |
|                              | Attendance and Class Participitation                                                                                                                                                                                                         |           |
| External Evaluation          | End Semester Examination                                                                                                                                                                                                                     | 75 Marks  |
|                              | Total                                                                                                                                                                                                                                        | 100 Marks |

| <b>Methods of Assessment</b> |                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

#### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | S    | M    |      | M    | S    |      |      |      |      |       |       |       |       |       |
| CO2 | S    |      |      | M    | S    |      |      |      |      |       | S     |       |       |       |
| CO3 |      |      |      |      | S    |      | S    | S    |      |       | S     |       |       |       |
| CO4 |      |      |      |      | S    | S    | S    | S    | S    |       |       |       |       |       |
| CO5 | M    |      |      |      | S    | M    | S    | S    |      |       |       |       |       |       |

| Subject Code | Subject Name   | Category                              | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------|----------------|---------------------------------------|---|---|---|---|---------|-------------|-------|----------|-------|
|              |                |                                       |   |   |   |   |         |             | CIA   | External | Total |
| 22MBP GE4A   | Bioinformatics | Elective Course IV Theory ( Choice 1) | Y | Y | - | - | 3       | 4           | 25    | 75       | 100   |

#### Course Objectives

|     |                                                               |
|-----|---------------------------------------------------------------|
| CO1 | Discuss about various biological data mining concepts, tools. |
|-----|---------------------------------------------------------------|

| CO2  | Elucidate the principles and applications of sequence alignment methods and tools.                                                                                                                                                                                                                                                                                                                                              |              |                   |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------------------|
| CO3  | Demonstrate different phylogenetic tree construction methods and its uses in phylogenetic analysis.                                                                                                                                                                                                                                                                                                                             |              |                   |
| CO4  | Acquaint with various approaches in predicting 3D and 2D structure of proteins.                                                                                                                                                                                                                                                                                                                                                 |              |                   |
| CO5  | Describe various tools and techniques used in molecular docking, immunoinformatics and subtractive genomics.                                                                                                                                                                                                                                                                                                                    |              |                   |
| UNIT | Details                                                                                                                                                                                                                                                                                                                                                                                                                         | No. of Hours | Course Objectives |
| I    | Biological Data Mining – Exploration of Data Mining Tools. Cluster Analysis Methods. Data Visualization. Biological Data Management. Biological Algorithms – Biological Primary and Derived Databases. Concept of Alignment, Pairwise Sequence Alignment (PSA), Multiple Sequence Alignment (MSA), BLAST, CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).       | 12           | CO1               |
| II   | Phylogenetic Tree Construction - Concept of Dendrograms. Evolutionary Trees - Distance Based Tree Reconstruction - Ultrametric trees and Ultrametric distances – Reconstructing Trees from Additive Matrices - Evolutionary Trees and Hierarchical Clustering - Character Based Tree Reconstruction - Maximum Parsimony Method, Maximum likelihood method - Reliability of Trees – Substitution matrices – Evolutionary models. | 12           | CO2               |
| III  | Computational Protein Structure prediction – Secondary structure – Homology modelling- Fold recognition and ab initio 3D structure prediction – Structure comparison and alignment – Prediction of function from structure. Geometrical parameters – Potential energy surfaces – Hardware and Software requirements-Molecular graphics – Molecular file formats-Molecular visualization tools.                                  | 12           | CO3               |
| IV   | Prediction of Properties of Ligand Compounds – 3D Autocorrelation -3D Morse Code-Conformation Dependent and Independent Chirality Codes –Comparative Molecular Field Analysis – 4 D QSAR –HYBOT Descriptors – Structure Descriptors – Applications – Linear Free Energy Relationships – Quantity Structure - Property Relationships –Prediction of the Toxicity of Compounds                                                    | 12           | CO4               |
| V    | Molecular Docking- Flexible - Rigid docking- Target- Ligand preparation- Solvent accessibility- Surface volume calculation, Active site prediction- Docking algorithms- Genetic, Lamarckian - Docking analyses- Molecular interactions, bonded and nonbonded - Molecular Docking Software and Working Methods. Genome to drug discovery – Subtractive Genomics – Principles of Immunoinformatics and Vaccine                    | 12           | CO5               |

|                  |                                                                                                                                                                                                    |                                     |  |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|--|
|                  | Development.                                                                                                                                                                                       |                                     |  |
|                  | Total                                                                                                                                                                                              | 60                                  |  |
| Course Outcomes  |                                                                                                                                                                                                    |                                     |  |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                       |                                     |  |
| CO1              | Access to databases that provides information on nucleic acids and proteins.                                                                                                                       | PO1, PO4, PO6, PO7, PO9, PO10, PO13 |  |
| CO2              | Invent algorithms for sequence alignment.                                                                                                                                                          | PO7, PO9, PO10, PO13                |  |
| CO3              | Construct phylogenetic tree.                                                                                                                                                                       | PO6, PO9, PO10                      |  |
| CO4              | Predict the structure of proteins.                                                                                                                                                                 | PO4, PO6, PO7, PO9, PO13            |  |
| CO5              | Design drugs by predicting drug ligand interactions and molecular docking.                                                                                                                         | PO4, PO5, PO6, PO7, PO9, PO10, PO13 |  |
| Text Books       |                                                                                                                                                                                                    |                                     |  |
| 1.               | Lesk A. M. (2002). Introduction to Bioinformatics. (4 <sup>th</sup> Edition). Oxford University Press.                                                                                             |                                     |  |
| 2.               | Lengauer T. (2008). Bioinformatics- from Genomes to Therapies (Vol-1).Wiley- VCH.                                                                                                                  |                                     |  |
| 3.               | Rastogi S. C., Mendiratta N. and Rastogi P. (2014). Bioinformatics - Methods and Applications (Genomics, Proteomics and Drug Discovery) (4 <sup>th</sup> Edition). Prentice-Hall of India Pvt.Ltd. |                                     |  |
| 4.               | Attwood, T.K. and Parry-Smith, D.J. (1999). Introduction to Bioinformatics. Addison Wesley Longman Limited, England.                                                                               |                                     |  |
| 5.               | Mount D.W., (2013).Bioinformatics sequence and genome analysis, 2 <sup>nd</sup> edn.CBS Publishers, New Delhi.                                                                                     |                                     |  |
| References Books |                                                                                                                                                                                                    |                                     |  |
| 1.               | Baxevanis A. D. and Ouellette F. (2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. (2 <sup>nd</sup> Edition). John Wiley and Sons.                                  |                                     |  |
| 2.               | Bosu O. and Kaur S. (2007). Bioinformatics - Database, Tools, and Algorithms. Oxford University Press.                                                                                             |                                     |  |
| 3.               | David W. M. (2001). Bioinformatics Sequence and Genome Analysis (2 <sup>nd</sup> Edition). CBS Publishers and Distributors(Pvt.)Ltd.                                                               |                                     |  |
| 4.               | Xiong J, (2011). <u>Essential bioinformatics</u> , First south Indian Edition, Cambridge University Press.                                                                                         |                                     |  |
| 5.               | Harshawardhan P.Bal, (2006). <u>Bioinformatics Principles and Applications</u> , Tata McGraw-Hill Publishing Company Limited.                                                                      |                                     |  |
| Web Resources    |                                                                                                                                                                                                    |                                     |  |

|                                    |                                                                                                                           |           |
|------------------------------------|---------------------------------------------------------------------------------------------------------------------------|-----------|
| 1.                                 | <a href="https://www.hsls.pitt.edu/obrc/">https://www.hsls.pitt.edu/obrc/</a>                                             |           |
| 2.                                 | <a href="https://www.hsls.pitt.edu/obrc/index.php?page=dna">https://www.hsls.pitt.edu/obrc/index.php?page=dna</a>         |           |
| 3.                                 | <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1669712/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1669712/</a> |           |
| 4.                                 | <a href="https://www.ebi.ac.uk/">https://www.ebi.ac.uk/</a>                                                               |           |
| 5.                                 | <a href="https://www.kegg.jp/kegg/kegg2.html">https://www.kegg.jp/kegg/kegg2.html</a>                                     |           |
| <b>Methods of Evaluation</b>       |                                                                                                                           |           |
| Internal<br>Evaluation             | Continuous Internal Assessment Tests                                                                                      | 25 Marks  |
|                                    | Assignments                                                                                                               |           |
|                                    | Seminars                                                                                                                  |           |
|                                    | Attendance and Class Participation                                                                                        |           |
| External<br>Evaluation             | End Semester Examination                                                                                                  | 75 Marks  |
|                                    | Total                                                                                                                     | 100 Marks |
| <b>Methods of Assessment</b>       |                                                                                                                           |           |
| Recall (KI)                        | Simple definitions, MCQ, Recall steps, Concept definitions                                                                |           |
| Understand /<br>Comprehend<br>(K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                            |           |
| Application<br>(K3)                | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                    |           |
| Analyse (K4)                       | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge           |           |
| Evaluate (K5)                      | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                    |           |
| Create (K6)                        | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                  |           |

### Mapping with Programme Outcomes

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-------|-------|-------|
| CO1 | M   |     |     | M   |     | M   |     |     | M   | M     |       |       | M     |       |
| CO2 |     |     |     |     |     |     | S   |     | S   | S     |       |       | S     |       |
| CO3 |     |     |     |     |     | S   |     |     | S   | S     |       |       |       |       |
| CO4 |     |     |     | S   |     | S   | S   |     | S   |       |       |       | S     |       |
| CO5 |     |     |     | S   | S   | S   | S   |     | S   | S     |       |       | S     |       |

| Subject Code             | Subject Name                                                                                                                                                                                                       | Category                     | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|---|---|---|---|---------|-------------|-------|----------|-------|
|                          |                                                                                                                                                                                                                    |                              |   |   |   |   |         |             | CIA   | External | Total |
| 22MBP GE5A               | Biosafety, Bioethics and IPR                                                                                                                                                                                       | Elective Course V (Choice 1) | Y | Y | - | - | 3       | 4           | 25    | 75       | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                    |                              |   |   |   |   |         |             |       |          |       |
| CO1                      | Create a research environment. Encourage investigation, analysis and study the bioethical principles, values, concepts, and social and juridical implications in the areas of science, biotechnology and medicine. |                              |   |   |   |   |         |             |       |          |       |
| CO2                      | Discuss about various aspects of biosafety regulations, IPR and bioethics concerns arising from the commercialization of biotechnological products.                                                                |                              |   |   |   |   |         |             |       |          |       |
| CO3                      | Familiarize fundamental aspects of Intellectual property Rights in the development and management of innovative projects in industries.                                                                            |                              |   |   |   |   |         |             |       |          |       |
| CO4                      | Acquire knowledge about bioethics, biodiversity and Genetically modified foods and food crops                                                                                                                      |                              |   |   |   |   |         |             |       |          |       |
| CO5                      | Provide students with an understanding of bioethics in research associated with medicine                                                                                                                           |                              |   |   |   |   |         |             |       |          |       |

| UNIT | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | No.of Hours | Course Objectives |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------|
| I    | Intellectual Property Rights: Different forms of Intellectual Property Rights – their relevance, importance to industry, Academia. Role of IPR's in Biotechnology, Patent Terminology - Patents, trademarks, copyrights, industrial designs, geographical indications, trade secrets, non-disclosure agreements. Patent life and geographical boundaries. International organizations and IPR - Overview of WTO, TRIPS, WIPO, GATT, International conventions, Trade agreements, Implication of TRIPS for developing countries. | 12          | CO1               |
| II   | Process involved in patenting. Patent Search - Procedural steps in patenting, process of filing, PCT application, pre-grant & post-grant opposition, PCT and patent harmonization including Sui-generis system, patent search methods, patent databases and libraries, online tools, Country-wise patent searches (USPTO, EPO, India etc.), patent mapping.                                                                                                                                                                     | 12          | CO2               |
| III  | Patentability of biotechnology inventions - Patentability of biotechnology inventions in India, statutory provisions regarding biotechnological inventions under the current Patent Act 1970 (as Amended 2005). Biotechnological                                                                                                                                                                                                                                                                                                | 12          | CO3               |

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                               |     |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----|
|                 | inventions as patentable subject matter, territorial nature of patents - from territorial to global patent regime, interpreting trips in the light of biotechnology inventions, feasibility of a uniform global patent system, merits and demerits of uniform patent law, relevance of the existing international patent, tentative harmonisation efforts, implications of setting up a uniform world patent system.                                                             |                               |     |
| IV              | Introduction to bioethics - need of bioethics, applications and issues related to bioethics, social and cultural issues. Bioethics and biodiversity - conserving natural biodiversity, convention on protecting biodiversity, protocols in exchanging biological material across borders. Bioethics & GMO's - issues and concerns pertaining to genetically modified foods and food crops, organisms and their possible health implications and mixing up with the gene-pool.    | 12                            | CO4 |
| V               | Bioethics in medicine - Protocols of ethical concerns related to prenatal diagnosis, gene therapy, organ transplantation, xeno transplantation, ethics in patient care, informed consent. bioethics and cloning - permissions and procedures in animal cloning, human cloning, risks and hopes. Bioethics in research: stem cell research, human genome project, use of animals in research, human volunteers for clinical research, studies on ethnic races. he Nuremberg code. | 12                            | CO5 |
|                 | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 60                            |     |
| Course Outcomes |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                               |     |
| Course Outcomes | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                                     |                               |     |
| CO1             | Execute the role of IPR, Patent, Trademarks and its importance.                                                                                                                                                                                                                                                                                                                                                                                                                  | PO1, PO2, PO3, PO5, PO6       |     |
| CO2             | Develop patent procedure, patent filling and its mapping.                                                                                                                                                                                                                                                                                                                                                                                                                        | PO3, PO4, PO13                |     |
| CO3             | Become Patent attorneys and Patent officers.                                                                                                                                                                                                                                                                                                                                                                                                                                     | PO2, PO3, PO4, PO7, PO9       |     |
| CO4             | Apply bioethics in GMO, food crops and its biodiversity.                                                                                                                                                                                                                                                                                                                                                                                                                         | PO2, PO3, PO5, PO9            |     |
| CO5             | Analyze the importance of bioethics in research associated with HGP, clinical research, stem cell therapy.                                                                                                                                                                                                                                                                                                                                                                       | PO1, PO3, PO5, PO6, PO9, PO10 |     |
| Text Books      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                               |     |
| 1.              | Usharani B., Anbazhagi S. and Vidya C. K. (2019). Biosafety in Microbiological                                                                                                                                                                                                                                                                                                                                                                                                   |                               |     |

|                              |                                                                                                                                                               |          |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|                              | Laboratories. (1 <sup>st</sup> Edition). Notion Press. ISBN-101645878856                                                                                      |          |
| 2.                           | Satheesh M. K. (2009). Bioethics and Biosafety. (1 <sup>st</sup> Edition). J. K International Publishing House Pvt. Ltd: Delhi. ISBN: 9788190675703           |          |
| 3.                           | Goel D. and Parashar S. (2013). IPR, Biosafety and Bioethics. (1 <sup>st</sup> Edition). Pearson education: Chennai. ISBN-13: 978-8131774700                  |          |
| 4.                           | Raj Mohan joshi. Biosafety and Bioethics. Wiley Publications.                                                                                                 |          |
| 5.                           | Sibi. GIntellectual, Property Rights, Bioethics, Biosafety and Entrepreneurship in biotechnology. (2021). Wiley Publications.                                 |          |
| <b>References Books</b>      |                                                                                                                                                               |          |
| 1.                           | Nithyananda K. V. (2019). Intellectual Property Rights: Protection and Management, India, IN: Cengage Learning India Private Limited.                         |          |
| 2.                           | Neeraj, P. and Khusdeep, D. (2014). Intellectual Property Rights, India, IN: PHI learning Private Limited,                                                    |          |
| 3.                           | Ahuja, V K. (2017). Law relating to Intellectual Property Rights, India, IN: Lexis Nexis.                                                                     |          |
| 4.                           | Tony Hope (2004). Medical Ethics: A very Short introduction,. Oxford Publication.                                                                             |          |
| 5.                           | Goel Parashar. IPR, Biosafety and Bioethics (2013). Pearson Publications.                                                                                     |          |
| <b>Web Resources</b>         |                                                                                                                                                               |          |
| 1.                           | <a href="http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf">http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf</a> .                                   |          |
| 2.                           | <a href="https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf">https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf</a> . |          |
| 3.                           | <a href="https://www.cdc.gov/training/quicklearns/biosafety/">https://www.cdc.gov/training/quicklearns/biosafety/</a>                                         |          |
| 4.                           | <a href="https://bioethics.msu.edu/what-is-bioethics">https://bioethics.msu.edu/what-is-bioethics</a>                                                         |          |
| 5.                           | <a href="https://www.wto.org/english/tratop_e/trips_e/intel1_e.htm">https://www.wto.org/english/tratop_e/trips_e/intel1_e.htm</a>                             |          |
| <b>Methods of Evaluation</b> |                                                                                                                                                               |          |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                          | 25 Marks |
|                              | Assignments                                                                                                                                                   |          |
|                              | Seminars                                                                                                                                                      |          |
|                              | Attendance and Class Participation                                                                                                                            |          |



|                              |                                                                                                                 |           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------|
| External Evaluation          | End Semester Examination                                                                                        | 75 Marks  |
|                              | Total                                                                                                           | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                 |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or Overview                                  |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |           |

#### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | S    | S    | S    |      | S    | S    |      |      |      |       |       |       |       |       |
| CO2 |      |      | S    | S    |      |      |      |      |      |       |       |       | M     |       |
| CO3 |      | S    | S    | S    |      |      | S    |      | S    |       |       |       |       |       |
| CO4 |      | S    | S    |      | S    |      |      |      | S    |       |       |       |       |       |
| CO5 | S    |      | S    |      | S    | S    |      |      | S    | M     |       |       |       |       |

| Subject Code             | Subject Name                          | Category                      | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------------------|---------------------------------------|-------------------------------|---|---|---|---|---------|-------------|-------|----------|-------|
|                          |                                       |                               |   |   |   |   |         |             | CIA   | External | Total |
| 22MBPG E4C               | Clinical Research And Clinical Trials | Elective Course IV (Choice 3) | Y | Y | - | - | 3       | 4           | 25    | 75       | 100   |
| <b>Course Objectives</b> |                                       |                               |   |   |   |   |         |             |       |          |       |

|             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                     |                          |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|--------------------------|
| CO1         | Provide an overview of history and methods involved in conducting clinical research.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                     |                          |
| CO2         | Design the principles involved in ethical, legal, and regulatory issues in clinical research on human subjects.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                     |                          |
| CO3         | Describe principles and issues involved in monitoring patient-oriented research.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| CO4         | Formulate a well- defined quality assurance and quality control plans.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     |                          |
| CO5         | Acquire business development skills in the area of clinical research.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                          |
| <b>UNIT</b> | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>No. of Hours</b> | <b>Course Objectives</b> |
| I           | Introduction to Clinical Research: Clinical Research: An Overview, Different types of Clinical Research. Clinical Pharmacology: Pharmacokinetics, Pharmacodynamics, Pharmacoepidemiology, Bioavailability, Bioequivalence, Terminologies and definition in Clinical Research. Drug Development Process: Drug Discovery Pipeline, Drug Discovery Process. Preclinical trail, Human Pharmacology (Phase-I), Therapeutic Exploratory trail (Phase-II), Therapeutic Confirmatory Trail (Phase-III) and Post marketing surveillance (Phase-IV).                                                                                      | 12                  | CO1                      |
| II          | Ethical Considerations and Guideline in Clinical Research: Historical guidelines in Clinical Research-Nuremberg code, Declaration of Helsinki, Belmont report. International Conference on Harmonization (ICH)-Brief history of ICH, Structure of ICH & ICH Harmonization Process, Guidelines for Good Clinical Practice. Regulation in Clinical Research- Drug and cosmetic act, FDA, Schedule-Y- Ethics Committee and their responsibilities. Clinical Research Regulatory Submission & approval Process- IND, NDA and ANDA submission Procedure. DCGI submission procedure. Other Regulatory authorities- EMEA, MHRA, PhRMA. | 12                  | CO2                      |
| III         | Clinical Trial Management: Key Stakeholders in Clinical Research, Ethics Committees and Institutional Review Board, Responsibilities of Sponsor. Responsibilities of Investigator, Protocol in Clinical Research Clinical Trial Design, Project Planning Project Managements - Informed Consent, Investigator's Brochure (IB), Selection of an Investigator and Site, Patient screening, Inclusion and exclusion criteria, Randomization, Blinding. Essential Documents in clinical research -IB, ICF, PIS, TMF, ISF, CDA & CTA.                                                                                                | 12                  | CO3                      |
| IV          | Quality Assurance, Quality Control & Clinical Monitoring: Defining the terminology-Quality, Quality system, Quality Assurance & Quality Control-QA audit plan. 21 CFR Part 11, Site Auditing, Sponsor Compliance and Auditing, SOP For Clinical Research-CRF Review & Source Data Verification, Drug Safety Reporting Corrective and                                                                                                                                                                                                                                                                                            | 12                  | CO4                      |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                           |     |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|-----|
|                  | preventative action process.                                                                                                                                                                                                                                                                                                                                                                                                                                        |                           |     |
| V                | Business Development in the Clinical Research Industry: Introduction & Stages of Business Development-Start-up Phase, Growth Phase, Maturity Phase, Decline Phase. Outsourcing in Clinical Research, Reasons for outsourcing to contract research organizations, The India Advantage, Scope and Future of CRO, List of Clinical Research Organizations in India, List of IT companies offering services in Clinical Research. Role of business development manager. | 12                        | CO5 |
|                  | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 60                        |     |
| Course Outcomes  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                           |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                        |                           |     |
| CO1              | Apprehend the Drug Development process and different phases of clinical trials.                                                                                                                                                                                                                                                                                                                                                                                     | PO1, PO2, PO3, PO5        |     |
| CO2              | Recognize the ethics and regulatory perspectives on clinical research trials activities.                                                                                                                                                                                                                                                                                                                                                                            | PO3, PO5, PO6, PO9        |     |
| CO3              | Accentuate about clinical trials management concepts and documentation process.                                                                                                                                                                                                                                                                                                                                                                                     | PO2, PO4, PO6, PO9        |     |
| CO4              | Accomplish quality assurance and quality control to ensure the protection of human subjects and the reliability of clinical trial results.                                                                                                                                                                                                                                                                                                                          | PO2, PO4. PO6. PO7, PO9   |     |
| CO5              | To nurture skills recitation to commercial start up and industriousness.                                                                                                                                                                                                                                                                                                                                                                                            | PO4, PO8, PO9, PO11, PO13 |     |
| Text Books       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                           |     |
| 1.               | Gallin J. I., Ognibene F. P. and Johnson L. L. (2007). Principles and Practice of Clinical Research. (4 <sup>th</sup> Edition). Elsevier, 2007.ISBN-10: 0128499052                                                                                                                                                                                                                                                                                                  |                           |     |
| 2.               | Friedman L. M., Furberg C. D. and Demets D. (1998). Fundamentals of Clinical Trials, Vol: XVIII. (3 <sup>rd</sup> Edition). Springer Science & Business Media.                                                                                                                                                                                                                                                                                                      |                           |     |
| 3.               | Hulley S. B., Cummings S. R., Browner W. S., Grady D. G. and Newman T. B. (2013). Designing Clinical Research. (4 <sup>th</sup> Edition). Jaypee Medical. ISBN-13: 978-1608318049.                                                                                                                                                                                                                                                                                  |                           |     |
| 4.               | Reed,G. (2004). Prescott and Dunn’s Industrial Microbiology, 4 <sup>th</sup> edn, CBS publication and distributors.                                                                                                                                                                                                                                                                                                                                                 |                           |     |
| 5.               | Himanshu B. Text book of Clinical Research, Pee Vee books.                                                                                                                                                                                                                                                                                                                                                                                                          |                           |     |
| References Books |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                           |     |
| 1.               | Friedman L.M., Fuberge C.D., DeMets D. and Reboussen, D.M. (2015). Fundamentals of Clinical Trials, Springer.                                                                                                                                                                                                                                                                                                                                                       |                           |     |
| 2.               | Browner W. S., (2012). Publishing and Presenting Clinical Research. (3 <sup>rd</sup> Edition). Lippincott Williams and Wilkins.                                                                                                                                                                                                                                                                                                                                     |                           |     |
| 3.               | Rondel R. K., Varley S. A. and Webb C. F. (2008). Clinical Data Management. (2 <sup>nd</sup> Edition). Wiley.                                                                                                                                                                                                                                                                                                                                                       |                           |     |

|                             |                                                                                                                                                                                                                                                           |           |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 4.                          | Peppler, H.J. and Pearl Man, D. (1979). Fermentation Technology, Vol 1 & 2, 2 <sup>nd</sup> Edition<br>Academic Press, London.                                                                                                                            |           |
| 5.                          | E1-Mansi, E.M.T., Bryce, C.F.A., Demain, A.L. and Allman,A.R. (2007). Fermentation Microbiology and Biotechnology. 2 <sup>nd</sup> Edition, CRC press, Taylor and Francis Group.                                                                          |           |
| Web Resources               |                                                                                                                                                                                                                                                           |           |
| 1                           | <a href="https://www.hzu.edu.in/uploads/2020/10/Textbook-of-Clinical-Trials-Wiley-(2004).pdf">https://www.hzu.edu.in/uploads/2020/10/Textbook-of-Clinical-Trials-Wiley-(2004).pdf</a>                                                                     |           |
| 2                           | <a href="https://www.routledge.com/A-Practical-Guide-to-Managing-Clinical-Trials/Pfeiffer-Wells/p/book/9780367497828">https://www.routledge.com/A-Practical-Guide-to-Managing-Clinical-Trials/Pfeiffer-Wells/p/book/9780367497828</a>                     |           |
| 3                           | <a href="https://www.auctoresonline.org/journals/clinical-research-and-clinical-trials">https://www.auctoresonline.org/journals/clinical-research-and-clinical-trials</a>                                                                                 |           |
| 4                           | <a href="https://www.who.int/health-topics/clinical-trials#tab=tab_1">https://www.who.int/health-topics/clinical-trials#tab=tab_1</a>                                                                                                                     |           |
| 5                           | <a href="https://www.cancerresearchuk.org/about-cancer/find-a-clinical-trial/what-clinical-trials-are/types-of-clinical-trials">https://www.cancerresearchuk.org/about-cancer/find-a-clinical-trial/what-clinical-trials-are/types-of-clinical-trials</a> |           |
| Methods of Evaluation       |                                                                                                                                                                                                                                                           |           |
| Internal Evaluation         | Continuous Internal Assessment Tests                                                                                                                                                                                                                      | 25 Marks  |
|                             | Assignments                                                                                                                                                                                                                                               |           |
|                             | Seminars                                                                                                                                                                                                                                                  |           |
|                             | Attendance and Class Participitation                                                                                                                                                                                                                      |           |
| External Evaluation         | End Semester Examination                                                                                                                                                                                                                                  | 75 Marks  |
|                             | Total                                                                                                                                                                                                                                                     | 100 Marks |
| Methods of Assessment       |                                                                                                                                                                                                                                                           |           |
| Recall (KI)                 | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                                                                                                                |           |
| Understand/ Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                                                                                                            |           |
| Application (K3)            | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain.                                                                                                                                                                   |           |
| Analyse (K4)                | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                                                                                                                           |           |
| Evaluate (K5)               | Longer essay/ Evaluation essay, Critique or justify with pros and cons.                                                                                                                                                                                   |           |
| Create (K6)                 | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations.                                                                                                                                                                 |           |

### Mapping with Programme Outcomes

|  |     |     |     |     |     |     |     |     |     |      |      |      |      |      |
|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
|  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|

|     |   |   |   |   |   |   |   |   |   |  |   |  |   |  |
|-----|---|---|---|---|---|---|---|---|---|--|---|--|---|--|
| CO1 | S | S | S |   | S |   |   |   |   |  |   |  |   |  |
| CO2 |   |   | S |   | S | S |   |   | S |  |   |  |   |  |
| CO3 |   | S |   | S |   | S |   |   | S |  |   |  |   |  |
| CO4 |   | S |   | S |   | S | S |   | S |  |   |  |   |  |
| CO5 |   |   |   | S |   |   |   | S | S |  | S |  | M |  |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Category                   | L | T | P | S | Credits | Inst. Hours | Marks        |                   |       |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---|---|---|---|---------|-------------|--------------|-------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                            |   |   |   |   |         |             | CIA          | External          | Total |
| 22MBP GSEC1              | Vermitechnology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Skill Enhancement Course 1 | Y | - | - | - | 2       | 2           | 25           | 75                | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                            |   |   |   |   |         |             |              |                   |       |
| CO1                      | Introduce the concepts of vermicomposting.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                            |   |   |   |   |         |             |              |                   |       |
| CO2                      | Explain the physiology, anatomy and biology of earthworms.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                            |   |   |   |   |         |             |              |                   |       |
| CO3                      | Acquire the knowledge of the vermicomposting process.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                            |   |   |   |   |         |             |              |                   |       |
| CO4                      | Explain the trouble shooting, harvesting and packaging of vermin composts.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                            |   |   |   |   |         |             |              |                   |       |
| CO5                      | Gain knowledge on applications of vermin composts and their value added products.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                            |   |   |   |   |         |             |              |                   |       |
| UNIT                     | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                            |   |   |   |   |         |             | No. of Hours | Course Objectives |       |
| I                        | Introduction to Vermiculture - Definition, classification, history, economic importance- In sustainable agriculture, organic farming, earthworm activities, soil fertility & texture, soil aeration, water impercolation, decomposition & moisture, bait & food and their value in maintenance of soil structure. Its role in the bio transformation of the residues generated by human activity and production of organic fertilizers. Choosing the right worm. Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Factors affecting distribution of earthworms in soil. |                            |   |   |   |   |         |             | 6            | CO1               |       |
| II                       | Earthworm Biology and Rearing - Key to identify the species of earthworms. Biology of <i>Eisenia fetida</i> . a) Taxonomy Anatomy, physiology and reproduction of Lumbricidae. b) Vital cycle of <i>Eisenia fetida</i> : alimentation, fecundity, annual reproducer potential and limiting factors (gases, diet, humidity, temperature, PH, light, and climatic factors). Biology of <i>Eudrilus eugeniae</i> . c) Taxonomy Anatomy, physiology and reproduction of Eudrilidae. d) Vital cycle of <i>Eudrilus eugeniae</i> :                                                                                    |                            |   |   |   |   |         |             | 6            | CO2               |       |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |    |     |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|-----|
|     | alimentation, fecundity, annual reproducer potential and limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors).                                                                                                                                                                                                                                                                                                                                                                                                 |    |     |
| III | Vermicomposting Process - Feeds for Vermitech systems- Animal manures- Kitchen Waste and Urban waste- Paper pulp and card board solids- Compost and waste products- Industrial Wastes. Vermicomposting Basic process- Initial pre-composting phase- Mesophilic phase- Maturing and stabilization phase- Mechanism of Earthworm action. Methods of vermicomposting- a) windrows system; b) wedge system; c) container system-pits, tanks & cement rings; commercial model; beds or bins-top fed type, stacked type, d) Continuous flow system. | 6  | CO3 |
| IV  | Vermicomposting - Trouble Shooting-Temperature-Aeration-Acidity- Pests and Diseases- Ants, rodents, Birds, Centipedes, sour crop, Mite pests. Odour problems. Separation techniques-Light Separation-Sideways Separation-Vertical Separation-Gradual transfer. Harvesting Earthworms- manual method-migration method. Packing & Nutritional analysis of vermicompost.                                                                                                                                                                         | 6  | CO4 |
| V   | Applications of Vermiculture - Vermiculture Bio-technology, use of vermi castings in organic farming/horticulture, as feed/bait for capture/culture fisheries; forest regeneration. Application quantity of vermicompost in Agricultural fields-crops, fruits, vegetables & flowers. By-products and value-added products- Verm wash- vermicompost tea-vermi meal-enriched vermicompost-pelleted vermicompost.                                                                                                                                | 6  | CO5 |
|     | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 30 |     |

#### Course Outcomes

| Course Outcomes | On completion of this course, students will;                                           |                         |
|-----------------|----------------------------------------------------------------------------------------|-------------------------|
| CO1             | Compare and contrast the uses of vermicompost to the soil.                             | PO1, PO4, PO5, PO9,     |
| CO2             | Recommend different species of earthworms after acquiring knowledge on its biology.    | PO1, PO4, PO6, PO9      |
| CO3             | Design the vermicomposting process.                                                    | PO1, PO4, PO6, PO7, PO8 |
| CO4             | Assess the Best Practices of Vermicomposting                                           | PO6,PO7, PO8,PO9,       |
| CO5             | Recommend the applications of vermicompost to different soils and for different crops. | PO1, PO4, PO5,PO6, PO7  |

#### Text Books

|   |                                                                                     |
|---|-------------------------------------------------------------------------------------|
| 1 | Ismail S. A. (2005). The Earthworm Book, Second Revised Edition. Other India Press, |
|---|-------------------------------------------------------------------------------------|

|                              |                                                                                                                                                                                                       |           |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|                              | Goa, India.                                                                                                                                                                                           |           |
| 2                            | Rathoure A. K., Bharati P. K. and Ray J. (2020). Vermitechnology, Farm and Fertilizer. Vermitechnology, Farm and Fertilizer Discovery Publishing House Pvt Ltd.                                       |           |
| 3                            | Christy M. V. 2008. Vermitechnology, (1 <sup>st</sup> Edition), MJP Publishers.                                                                                                                       |           |
| 4                            | The complete technology book on Vermiculture and Vermicompost with manufacturing Process, machinery equipment details and Plant Layout. AB Press.                                                     |           |
| 5                            | Keshav Singh (2014). A Textbook of vermicompost: Vermiwash and Biopesticide.                                                                                                                          |           |
| References Books             |                                                                                                                                                                                                       |           |
| 1                            | Roy D. (2018). Handbook of Vermitechnology. Lambert Academic Publishing.                                                                                                                              |           |
| 2                            | Kumar A. (2005). Verms and Vermitechnology, A.P.H. Publishing Corporation, New Delhi.                                                                                                                 |           |
| 3                            | Lekshmy M. S., Santhi R. (2012). Vermitechnology, Sara Publications, New Delhi, India.                                                                                                                |           |
| 4                            | <u>Edwards CA, Arancon NQ ShermanRL. (2011) Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management 1<sup>st</sup> edn.CRC Press.</u>                                       |           |
| 5                            | <u>Ismail, S.A. (1997). Vermicology-The Biology of Earthworm.1<sup>st</sup> edn. Orient longman.</u>                                                                                                  |           |
| Web Resources                |                                                                                                                                                                                                       |           |
| 1.                           | <a href="https://en.wikipedia.org/wiki/Vermicompost">https://en.wikipedia.org/wiki/Vermicompost</a>                                                                                                   |           |
| 2.                           | <a href="http://stjosephs.edu.in/upload/papers/9567411a78c63d4ccfbbe85e6aa22840.pdf">http://stjosephs.edu.in/upload/papers/9567411a78c63d4ccfbbe85e6aa22840.pdf</a>                                   |           |
| 3.                           | <a href="https://www.kngac.ac.in/elearning-portal/ec/admin/contents/4_18K4ZEL02_2021012803204629.pdf">https://www.kngac.ac.in/elearning-portal/ec/admin/contents/4_18K4ZEL02_2021012803204629.pdf</a> |           |
| 4.                           | <a href="https://composting.ces.ncsu.edu/vermicomposting-2/">https://composting.ces.ncsu.edu/vermicomposting-2/</a>                                                                                   |           |
| 5.                           | <a href="https://rodaleinstitute.org/science/articles/vermicomposting-for-beginners/">https://rodaleinstitute.org/science/articles/vermicomposting-for-beginners/</a>                                 |           |
| Methods of Evaluation        |                                                                                                                                                                                                       |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                                                  | 25 Marks  |
|                              | Assignments                                                                                                                                                                                           |           |
|                              | Seminars                                                                                                                                                                                              |           |
|                              | Attendance and Class Participation                                                                                                                                                                    |           |
| External Evaluation          | End Semester Examination                                                                                                                                                                              | 75 Marks  |
|                              | Total                                                                                                                                                                                                 | 100 Marks |
| Methods of Assessment        |                                                                                                                                                                                                       |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                                                            |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                                                        |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                                                                |           |

|               |                                                                                                                 |
|---------------|-----------------------------------------------------------------------------------------------------------------|
| Analyse (K4)  | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)   | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

### Mapping with Programme Outcomes

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| CO1 | S   |     |     | M   | S   |     |     |     | S   |      |      |      |      |      |
| CO2 | S   |     |     | M   |     | S   |     |     | S   |      |      |      |      |      |
| CO3 | S   |     |     | S   |     | S   | S   | S   |     |      |      |      |      |      |
| CO4 |     |     |     |     |     | S   | S   | S   | S   |      |      |      |      |      |
| CO5 | S   |     |     | M   | S   | M   | S   |     |     |      |      |      |      |      |

### SECONDYEAR THIRD SEMESTER

| Subject Code             | Subject Name                                                                                                           | Category        | L | T | P | S | Credits | Inst. Hours | Marks |                     |                          |
|--------------------------|------------------------------------------------------------------------------------------------------------------------|-----------------|---|---|---|---|---------|-------------|-------|---------------------|--------------------------|
|                          |                                                                                                                        |                 |   |   |   |   |         |             | CI A  | External            | Total                    |
| 22MBPGCT2                | Immunology, Immunotechnology and Microbial Genetics                                                                    | Core Course VII | Y | Y | - | - | 4       | 6           | 25    | 75                  | 100                      |
| <b>Course Objectives</b> |                                                                                                                        |                 |   |   |   |   |         |             |       |                     |                          |
| CO1                      | Discuss immunity, organs and cells involved in immunity. Compare the types of antigens and their properties.           |                 |   |   |   |   |         |             |       |                     |                          |
| CO2                      | Describe immunoglobulin and its types. Categorize MHC and understand its significance.                                 |                 |   |   |   |   |         |             |       |                     |                          |
| CO3                      | Elucidate the mechanisms of different hypersensitivity reactions. List out the Vaccines and discuss their development. |                 |   |   |   |   |         |             |       |                     |                          |
| CO4                      | Acquire knowledge the structure DNA in prokaryotes and eukaryotes                                                      |                 |   |   |   |   |         |             |       |                     |                          |
| CO5                      | Explain out gene transfer studies in microbes.                                                                         |                 |   |   |   |   |         |             |       |                     |                          |
| <b>UNIT</b>              | <b>Details</b>                                                                                                         |                 |   |   |   |   |         |             |       | <b>No. of Hours</b> | <b>Course Objectives</b> |
| I                        | Introduction to biology of the immune system – Cells and organs of Immune System. T and B lymphocytes – Origin,        |                 |   |   |   |   |         |             |       | 20                  | CO1                      |



|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |     |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|-----|
|     | development, differentiation, lymphocyte subpopulation in humans. Innate immunity- Complement, Toll-like receptors and other components. Acquired immunity – Active and Passive immunity. Antigens - features associated with antigenicity and immunogenicity. Basis of antigen specificity. MHC genes and products, Structure of MHC molecules, Genetics of HLA Systems – Antigens and HLA typing. Antigen processing and presentation to T-lymphocytes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |    |     |
| II  | Immunoglobulins. Theories of antibody production. Class switching and generation of antibody diversity. Monoclonal and polyclonal antibodies. Complement system – mode of activation- Classical, Alternate and Lectin pathways, biological functions. Antigen recognition – TCR, Diversity of TCR, T cell surface alloantigens, lymphocyte activation, clonal proliferation and differentiation. Physiology of acquired immune response – various phases of HI, CMI – Cell mediated cytotoxicity, DTH response.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 20 | CO2 |
| III | Hypersensitivity – Types and mechanisms, Autoimmunity, Tumor Immunity and Transplantation immunology. Immunodeficiency-Primary immunodeficiency and Secondary immunodeficiencies. Genetics of Immunohematology – Genetic basis and significance of ABO and other minor blood groups in humans, Bombay blood group, Secretors and Non-secretors, Rh System and genetic basis of D- antigens.<br>Diagnostic Immunology - Precipitation reaction, Immunodiffusion methods - SRID, ODD. Immunoelectrophoresis - Rocket and Counter current electrophoresis. Agglutination - Hemagglutination - Hemagglutination inhibition. Labeled Assay-Immunofluorescence assay, Radio immunoassay, FISH, ELISA. Flow cytometry. Immune regulation mechanisms – immuno-induction, immuno- suppression, immuno-tolerance, immuno-potentiation, Immunomodulation. Role of cytokines, lymphokines and chemokines. Introduction to Vaccines and Adjuvants - Types of vaccines. Development of vaccines and antibodies in plants.<br>Immunomics - Introduction and Applications. Antigen engineering for better immunogenicity and use for vaccine development-multiepitope vaccines. Reverse vaccinology. | 25 | CO3 |
| IV  | Structural of prokaryotic and eukaryotic genome. Introduction to prokaryotic genomic structure, Eukaryotic Genome - Structure of chromatin, chromosome, centromere, telomere, nucleosome. Modifications- methylation,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 13 | CO4 |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |     |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----|
|                  | acetylation, phosphorylation and its effect on structure and function of chromatin, DNA methylation and gene imprinting, organelle genome.                                                                                                                                                                                                                                                                                                         |                               |     |
| V                | Gene Transfer Mechanisms- Conjugation and its uses. Transduction, Generalized and Specialized, Transformation– Natural Competence and Transformation. Transposition and Types of Transposition reactions. Insertion sequences, complex and compound transposons – T10, T5, and Retroposon. Mechanism – Transposons of <i>E. coli</i> , Bacteriophage and Yeast. Importance of transposable elements in horizontal transfer of genes and evolution. | 12                            | CO5 |
|                  | Total                                                                                                                                                                                                                                                                                                                                                                                                                                              | 60                            |     |
| Course Outcomes  |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                       |                               |     |
| CO1              | Categorize the immune response to a variety of antigens. Identify different immune cells involved in immunity.                                                                                                                                                                                                                                                                                                                                     | PO1, PO4, PO6, PO7, PO9       |     |
| CO2              | Justify the significance of MHC molecules in immune response and antibody production.                                                                                                                                                                                                                                                                                                                                                              | PO1, PO4, PO5, PO6, PO9       |     |
| CO3              | Design antibodies and evaluate immunological assays in patient samples.                                                                                                                                                                                                                                                                                                                                                                            | PO4, PO6, PO7, PO8, PO9, PO10 |     |
| CO4              | Analyze genomic DNA of prokaryotes and eukaryotes.                                                                                                                                                                                                                                                                                                                                                                                                 | PO4, PO5, PO6, PO7, PO9, PO10 |     |
| CO5              | Summarize gene transfer mechanisms for experimental study.                                                                                                                                                                                                                                                                                                                                                                                         | PO4, PO5, PO6, PO7, PO9, PO10 |     |
| Text Books       |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |     |
| 1.               | Coico R., Sunshine G. and Benjamini E. (2003). Immunology – A Short Course. (5 <sup>th</sup> Edition). Wiley-Blackwell, New York.                                                                                                                                                                                                                                                                                                                  |                               |     |
| 2.               | Owen J. A., Punt J., Stranford S. A. and Kuby J. (2013). Immunology, (7 <sup>th</sup> Edition). W. H. Freeman and Company, New York.                                                                                                                                                                                                                                                                                                               |                               |     |
| 3.               | Abbas A. K., Lichtman A. H. and Pillai S. (2021). Cellular and Molecular Immunology. (10 <sup>th</sup> Edition). Elsevier.                                                                                                                                                                                                                                                                                                                         |                               |     |
| 4.               | Malacinski G.M. (2008). Freifelder’s Essentials of Molecular Biology. (4 <sup>th</sup> Edition). Narosa Publishing House, New Delhi.                                                                                                                                                                                                                                                                                                               |                               |     |
| 5.               | Gardner E. J. Simmons M. J. and Snusted D.P. (2006). Principles of Genetics. (8 <sup>th</sup> Edition). Wiley India Pvt. Ltd.                                                                                                                                                                                                                                                                                                                      |                               |     |
| References Books |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |     |
| 1.               | Travers J. (1997). Immunobiology - The Immune System in Health and Disease. (3 <sup>rd</sup> Edition). Current Biology Ltd. New York.                                                                                                                                                                                                                                                                                                              |                               |     |
| 2.               | Delves P.J., Martin S., Burton D. R. and Roitt I. M. (2006). Roitt’s Essential Immunology. (11 <sup>th</sup> Edition). Wiley-Blackwell.                                                                                                                                                                                                                                                                                                            |                               |     |
| 3.               | Hay F. C. and Westwood O. M. R. ( 2002). Practical Immunology (4 <sup>th</sup> Edition). Wiley-Blackwell.                                                                                                                                                                                                                                                                                                                                          |                               |     |

|                              |                                                                                                                                                                                                                         |           |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 4.                           | Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5 <sup>th</sup> Edition). ASM Press.                                                                     |           |
| 5.                           | Russell P.J. (2010). Genetics - A Molecular Approach. (3 <sup>rd</sup> Edition). Pearson New International Edition.                                                                                                     |           |
| <b>Web Resources</b>         |                                                                                                                                                                                                                         |           |
| 1.                           | <a href="https://www.ncbi.nlm.nih.gov/books/NBK279395/">https://www.ncbi.nlm.nih.gov/books/NBK279395/</a>                                                                                                               |           |
| 2.                           | <a href="https://med.stanford.edu/immunol/phd-program/ebook.html">https://med.stanford.edu/immunol/phd-program/ebook.html</a>                                                                                           |           |
| 3.                           | <a href="https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/">https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/</a> |           |
| 4.                           | [PDF] Lehninger Principles of Biochemistry (8 <sup>th</sup> Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in                                                                       |           |
| 5.                           | <a href="https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/">https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/</a>                                         |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                                                                                         |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                                                                    | 25 Marks  |
|                              | Assignments                                                                                                                                                                                                             |           |
|                              | Seminars                                                                                                                                                                                                                |           |
|                              | Attendance and Class Participation                                                                                                                                                                                      |           |
| External Evaluation          | End Semester Examination                                                                                                                                                                                                | 75 Marks  |
|                              | Total                                                                                                                                                                                                                   | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                                                                                                                         |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                                                                              |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                                                                          |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                                                                                  |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                                                                                         |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                                                                                                                  |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                                                                                                                |           |

### Mapping with Programme Outcomes

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-------|-------|-------|
| CO1 | S   |     |     | M   |     | M   | S   |     | S   |       |       |       |       |       |
| CO2 | S   |     |     | S   | M   | S   |     |     | S   |       |       |       |       |       |
| CO3 |     |     |     | S   |     | S   | S   | S   | S   | M     |       |       |       |       |
| CO4 |     |     |     | S   | M   | S   | M   |     | S   | M     |       |       |       |       |
| CO5 |     |     |     | S   | M   | S   | M   |     | S   | S     |       |       |       |       |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Category                | L | T | P | S | Credits | Inst. Hours | Marks        |                   |       |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---|---|---|---|---------|-------------|--------------|-------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                         |   |   |   |   |         |             | CIA          | External          | Total |
| 22MBP GCT8               | Molecular Biology and Recombinant DNA Technology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Core Course VIII Theory | 4 | 2 | - | - | 4       | 6           | 25           | 75                | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                         |   |   |   |   |         |             |              |                   |       |
| CO1                      | Provide knowledge on the structure, replication and repair mechanisms of DNA. Illustrate the structure, functions and significance of RNA.                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                         |   |   |   |   |         |             |              |                   |       |
| CO2                      | Discuss the gene regulatory mechanisms in prokaryotes and eukaryotes and importance of mutations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                         |   |   |   |   |         |             |              |                   |       |
| CO3                      | Provide in depth knowledge about artificial gene transfer mechanisms and selection of Recombinants.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                         |   |   |   |   |         |             |              |                   |       |
| CO4                      | Impart knowledge on various molecular techniques and their importance in biotechnology.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                         |   |   |   |   |         |             |              |                   |       |
| CO5                      | Explain the applications of genetic engineering in various fields.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                         |   |   |   |   |         |             |              |                   |       |
| UNIT                     | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                         |   |   |   |   |         |             | No. of Hours | Course Objectives |       |
| I                        | DNA replication – modes and enzymes involved. Detailed mechanism of semi-conservative replication. Prokaryotic and eukaryotic transcription. Structure and processing of m-RNA, r-RNA and t-RNA. Ribosomes. Genetic Code and Wobble hypothesis, Translation in prokaryotes and eukaryotes, post translational modifications.                                                                                                                                                                                                                                                                           |                         |   |   |   |   |         |             | 20           | CO1               |       |
| II                       | Gene regulation and expression – Lac operon, arabinose and tryptophan operons. Gene regulation in eukaryotic systems - repetitive DNA, gene rearrangement, promoters, enhancer elements. Molecular basis of gene mutation - Types of mutations - base substitutions, frame shift, deletion insertion, duplication, inversion. Silent, conditional and lethal mutation. Chemical mutagenesis. Repair of DNA damage. Photoreactivation. SOS repair mechanism. Base excision repair. Nucleotide excision repair. Detection and analysis of mutations (Replica plating, Antibiotic enrichment, Ames test). |                         |   |   |   |   |         |             | 20           | CO2               |       |
| III                      | Tools and methods in gene cloning. Restriction endonucleases – nomenclature, classification and characteristics - DNA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                         |   |   |   |   |         |             | 20           | CO3               |       |

|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |    |     |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|-----|
|                        | <p>methylases, DNA polymerases, Ligases. Adapters, linkers and homopolymer tailing. Artificial gene transfer techniques - electroporation, microinjection, protoplast fusion and microparticle bombardment. Screening for recombinants. Gene cloning vectors for prokaryotes and eukaryotes - cloning properties and types of plasmids vectors (pBR322 and derivatives, pUC vectors and pGEM3Z) - Phage Vectors(M13 and Lambda), cosmids, phasmids, phagemids and BACs - Eukaryotic vectors - Yeast vectors – Animal and plant vectors – expression vectors. Shuttle vectors - Expression of foreign genes in bacteria, animal, plant, algae and fungi – merits and demerits.</p>                                                                                                                                                                                                                           |    |     |
| IV                     | <p>Genomic DNA and cDNA library - Construction and Screening. Substrative hybridization for tissue specific DNA libraries. Techniques in genetic engineering Characterization of cloned DNA: Hybrid arrested translation (HAT) - Restriction mapping - restriction fragment length polymorphism (RFLP) - Polymerase chain reaction (PCR) – Principles, types and their applications. DNA sequencing - Primer walking, Sanger’s method and automated sequencing methods. Pyrosequencing – DNA chips and micro array. Protein engineering and techniques Site directed mutagenesis – methods - Design and construction of novel proteins and enzymes, Basic concepts in enzyme engineering, engineering for kinetic properties of enzymes. protein folding, protein sequencing, protein crystallization. Applications of protein engineering.</p>                                                             | 15 | CO4 |
| V                      | <p>Plant biotechnology - constituents and concepts of sterilization - preparation, isolation and selection of explant. Suspension cell culture, callus culture, protoplast isolation, culture &amp; fusion. Anther and pollen culture for production. Animal biotechnology – equipment and media used for animal cell culture technology. Primary and established cell line culture and culture media. Applications of animal cell cultures. Serum protein media viability and cytotoxicity. Applications of Genetic Engineering - transgenic animals, Recombinant Cytokines and their use in the treatment of animal infections. Monoclonal Antibodies in Therapy- Vaccines and their Applications in Animal Infections - Human Gene Therapy - Germline and Somatic Cell Therapy - Ex-vivo Gene Therapy. In-vivo Gene Therapy. Vectors in Gene Therapy-Viral and Non-Viral Vectors. Transgenic Plants.</p> | 15 | CO5 |
|                        | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 90 |     |
| <b>Course Outcomes</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |    |     |

|                        |                                                                                                                                                                                 |                                        |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| <b>Course Outcomes</b> | On completion of this course, students will;                                                                                                                                    |                                        |
| CO1                    | Analyze, demonstrate and appreciate DNA replication and protein synthesis.                                                                                                      | PO4, PO6, PO9                          |
| CO2                    | Investigate the types of mutation and its impact on microbes. Illustrate various strategies on gene cloning.                                                                    | PO4, PO6, PO9                          |
| CO3                    | Analyze, modify and characterize DNA modifying enzymes.                                                                                                                         | PO4, PO6, PO9                          |
| CO4                    | Illustratively assess the molecular techniques for DNA and protein analysis.                                                                                                    | PO4, PO6, PO9                          |
| CO5                    | Adopt the applications of Genetic Engineering in the field of agriculture and medicine towards scientific research.                                                             | PO1, PO3, PO4, PO5, PO6, PO7, PO8, PO9 |
| <b>Text Books</b>      |                                                                                                                                                                                 |                                        |
| 1.                     | Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4 <sup>th</sup> Edition). Narosa Publishing House, New Delhi.                                            |                                        |
| 2.                     | Snusted D.P. and Simmons M. J. (2019). Principles of Genetics. (7 <sup>th</sup> Edition). John Wiley and Soms, Inc.                                                             |                                        |
| 3.                     | Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3 <sup>rd</sup> Edition). John Wileys and Sons Ltd.          |                                        |
| 4.                     | Primrose S.B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics. (7 <sup>th</sup> Edition). Blackwell Publishing.                                           |                                        |
| 5.                     | Maloy S. R. Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2 <sup>nd</sup> Edition). Narosa Publishing House Pvt. Ltd.                                          |                                        |
|                        | <b>References Books</b>                                                                                                                                                         |                                        |
| 1.                     | Brown T. A. (2016). Gene Cloning and DNA Analysis- An Introduction. (7 <sup>th</sup> Edition). John Wiley and Sons, Ltd.                                                        |                                        |
| 2.                     | Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5 <sup>th</sup> Edition). ASM Press.                             |                                        |
| 3.                     | Russell P.J. (2010). Genetics - A Molecular Approach. (3 <sup>rd</sup> Edition). Pearson New International Edition.                                                             |                                        |
| 4.                     | Synder L., Peters J. E., Henkin T.M. and Champness W. (2013). Molecular Genetics of Bacteria. (4th Edition). ASM Press Washington-D.C. ASM Press.                               |                                        |
| 5.                     | Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3 <sup>rd</sup> Edition). John Wileys and Sons Ltd.          |                                        |
| <b>Web Resources</b>   |                                                                                                                                                                                 |                                        |
| 1.                     | <a href="https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/">https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/</a> |                                        |
| 2.                     | <a href="https://geneticeducation.co.in/what-is-transcriptomics">https://geneticeducation.co.in/what-is-transcriptomics</a>                                                     |                                        |
| 3.                     | <a href="https://www.molbiotools.com/usefullinks.html">https://www.molbiotools.com/usefullinks.html</a>                                                                         |                                        |

|                              |                                                                                                                                                                         |           |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 4.                           | <a href="https://geneticeeducation.co.in/what-is-transcriptomics">https://geneticeeducation.co.in/what-is-transcriptomics</a>                                           |           |
| 5.                           | <a href="https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/">https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/</a> |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                                         |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                    | 25 Marks  |
|                              | Assignments                                                                                                                                                             |           |
|                              | Seminars                                                                                                                                                                |           |
|                              | Attendance and Class Participation                                                                                                                                      |           |
| External Evaluation          | End Semester Examination                                                                                                                                                | 75 Marks  |
|                              | Total                                                                                                                                                                   | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                                                                         |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                              |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                          |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                                  |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                                         |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                                                                  |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                                                                |           |

#### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 |      |      |      | S    | M    | S    | L    | L    | S    | L     | L     |       |       |       |
| CO2 |      |      |      | S    | M    | S    | L    | L    | S    | L     | M     |       |       |       |
| CO3 |      |      |      | S    | M    | S    | L    | L    | S    | L     | M     |       |       |       |
| CO4 |      |      |      | S    | M    | S    | L    | L    | S    | L     | L     |       |       |       |
| CO5 | S    |      | S    | S    | S    | S    | S    | S    | S    | M     | L     |       |       |       |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Category                  | L | T | P | S | Credits | Inst. Hours | Marks        |                   |       |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|---|---|---|---|---------|-------------|--------------|-------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                           |   |   |   |   |         |             | CIA          | External          | Total |
| 22MBP GCP3               | Practical III – Immunology, Microbial Genetics and Molecular Biology                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Core Course IX Practicals | - | - | 6 | - | 4       | 6           | 40           | 60                | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                           |   |   |   |   |         |             |              |                   |       |
| CO1                      | Acquire adequate skills to perform blood grouping and serological reactions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                           |   |   |   |   |         |             |              |                   |       |
| CO2                      | Provide fundamental skills in preparation, separation and purification of immunoglobulin.                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                           |   |   |   |   |         |             |              |                   |       |
| CO3                      | Illustrate the significance of artificial transformation and mutations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                           |   |   |   |   |         |             |              |                   |       |
| CO4                      | Familiarize with routine molecular biological techniques.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                           |   |   |   |   |         |             |              |                   |       |
| CO5                      | Discuss blotting techniques and PCR.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                           |   |   |   |   |         |             |              |                   |       |
| UNIT                     | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                           |   |   |   |   |         |             | No. of Hours | Course Objectives |       |
| I                        | Hematological reactions - Blood Grouping – forward and reverse, Rh Typing<br>Identification of various immune cells by morphology – Leishman staining, Giemsa staining.<br>Agglutination Reactions- Latex Agglutination reactions- RF, ASO, CRP.Detection of HBs Ag by ELISA.<br>Precipitation reactions in gels– Ouchterlony double immunodiffusion (ODD) and Mancini's single radial immunodiffusion (SRID)<br>Immuno-electrophoresis and staining of precipitin lines-Rocket immuno electrophoresis and counter current immuno electrophoresis. |                           |   |   |   |   |         |             | 20           | CO3               |       |
| II                       | Preparation of lymphocytes from peripheral blood by density gradient centrifugation.<br>Purification of immunoglobulin– Ammonium Sulphate Precipitation.<br>Separation of IgG by chromatography using DEAE cellulose or Sephadex.                                                                                                                                                                                                                                                                                                                  |                           |   |   |   |   |         |             | 10           | CO4               |       |
| III                      | Artificial Transformation<br>Detection of Antibiotic resistant mutants<br>Identification of mutants by replica plating method.                                                                                                                                                                                                                                                                                                                                                                                                                     |                           |   |   |   |   |         |             | 20           | CO5               |       |



|                  |                                                                                                                                                                                                                   |                           |     |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|-----|
| IV               | Isolation of genomic DNA from <i>E. coli</i> and analysis by agarose gel electrophoresis<br>Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE)<br>Plasmid DNA isolation from <i>E.coli</i> . | 20                        | CO4 |
| V                | Amplification of DNA by PCR<br>Western blotting - Demonstration<br>Southern blotting – Demonstration                                                                                                              | 20                        | CO5 |
|                  | Total                                                                                                                                                                                                             | 90                        |     |
| Course Outcomes  |                                                                                                                                                                                                                   |                           |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                                      |                           |     |
| CO1              | Perform and evaluate immunological reactions to aid diagnosis.                                                                                                                                                    | PO4, PO6, PO7, PO9, PO11  |     |
| CO2              | Assess the level of lymphocytes in a blood sample and purify immunoglobulin employing appropriate techniques.                                                                                                     | PO4, PO6, PO7, PO10, PO11 |     |
| CO3              | Perform DNA extraction and gene transfer mechanisms, analyze and identify by gel electrophoresis                                                                                                                  | PO1, PO4, PO5, PO7, PO8   |     |
| CO4              | Utilize various molecular techniques for gene manipulation and detection of mutants.                                                                                                                              | PO1, PO4, PO5, PO7, PO8   |     |
| CO5              | Undertake novel research with techniques like PCR and blotting analysis.                                                                                                                                          | PO5, PO10                 |     |
| Text Books       |                                                                                                                                                                                                                   |                           |     |
| 1.               | Roitt R.I.M (2001). Essential Immunology.10 <sup>th</sup> Edn. Blackwell Scientific Publishers.                                                                                                                   |                           |     |
| 2.               | Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5 <sup>th</sup> Edition). ASM Press.                                                               |                           |     |
| 3.               | Gunasekaran P. (2007). Laboratory Manual in Microbiology. New Age International.                                                                                                                                  |                           |     |
| 4.               | James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5 <sup>th</sup> Edition). The Benjamin publishing company. New York.                                                         |                           |     |
| 5.               | Russell P. J. (2019). Genetics – A Molecular Approach (3 <sup>rd</sup> Edition). Pearson Education, Inc.                                                                                                          |                           |     |
| References Books |                                                                                                                                                                                                                   |                           |     |
| 1.               | Stites D.P., Abba I.Terr, Parslow T.G.(1997). Medical Immunology. 9 <sup>th</sup> edn, Prentice-Hall Inc.                                                                                                         |                           |     |
| 2.               | Tizard, R.I.(2000) Immunology- An Introduction. 4 <sup>th</sup> edn. Saunders College Publishing, Philadelphia.                                                                                                   |                           |     |
| 3.               | Dale J. W., Schantz M. V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3 <sup>rd</sup> Edition). John Wileys and Sons Ltd.                                           |                           |     |
| 4.               | Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7 <sup>th</sup>                                                                                                                     |                           |     |

|                              |                                                                                                                                                               |           |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|                              | Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press.                                                                                       |           |
| 5.                           | Brown T.A. (2016). Gene Cloning and DNA Analysis. (7 <sup>th</sup> Edition). John Wiley and Jones, Ltd.                                                       |           |
| Web Resources                |                                                                                                                                                               |           |
| 1.                           | <a href="https://www.molbiotools.com/usefullinks.html">https://www.molbiotools.com/usefullinks.html</a>                                                       |           |
| 2.                           | <a href="https://geneticgenie.org3">https://geneticgenie.org3</a> .                                                                                           |           |
| 3.                           | <a href="https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5">https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5</a> |           |
| 4.                           | <a href="https://vlab.amrita.edu/index.php?sub=3&amp;brch=272">https://vlab.amrita.edu/index.php?sub=3&amp;brch=272</a>                                       |           |
| 5.                           | <a href="https://nptel.ac.in/courses/102105087">https://nptel.ac.in/courses/102105087</a>                                                                     |           |
| Methods of Evaluation        |                                                                                                                                                               |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                          | 40 Marks  |
|                              | Attendance and Class Participitation                                                                                                                          |           |
| External Evaluation          | End Semester Examination                                                                                                                                      | 60 Marks  |
|                              | Total                                                                                                                                                         | 100 Marks |
| Methods of Assessment        |                                                                                                                                                               |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                    |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                        |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                                               |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                                                                        |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                                                                      |           |

### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 |      |      |      | S    | M    | S    | S    | M    | S    | M     | S     |       |       |       |
| CO2 |      |      |      | S    | M    | S    | S    | M    | M    | S     | S     |       |       |       |

|     |   |  |  |   |   |  |   |   |  |   |  |  |  |  |
|-----|---|--|--|---|---|--|---|---|--|---|--|--|--|--|
| CO3 | M |  |  | S | S |  | S | M |  |   |  |  |  |  |
| CO4 | M |  |  | S | S |  | S | S |  |   |  |  |  |  |
| CO5 |   |  |  |   | M |  |   |   |  | M |  |  |  |  |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                    | Category              | L | T | P | S | Credits | Inst. Hours | Marks        |                   |       |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---|---|---|---|---------|-------------|--------------|-------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                 |                       |   |   |   |   |         |             | CIA          | External          | Total |
| 22M BPG CT7              | Soil Microbiology and Microbial Ecology                                                                                                                                                                                                                                                                                                                         | Elective V (Choice 1) | Y | Y | - | - | 4       | 6           | 25           | 75                | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                 |                       |   |   |   |   |         |             |              |                   |       |
| CO1                      | Explain the role of microorganisms in soil fertility.                                                                                                                                                                                                                                                                                                           |                       |   |   |   |   |         |             |              |                   |       |
| CO2                      | Discuss the harmful effects of micro organisms in soil.                                                                                                                                                                                                                                                                                                         |                       |   |   |   |   |         |             |              |                   |       |
| CO3                      | Create awareness. about microbial interactions.                                                                                                                                                                                                                                                                                                                 |                       |   |   |   |   |         |             |              |                   |       |
| CO4                      | Acquire in depth knowledge about microbial communities and ecosystem.                                                                                                                                                                                                                                                                                           |                       |   |   |   |   |         |             |              |                   |       |
| CO5                      | Develop knowledge about quantitative ecology.                                                                                                                                                                                                                                                                                                                   |                       |   |   |   |   |         |             |              |                   |       |
| UNIT                     | Details                                                                                                                                                                                                                                                                                                                                                         |                       |   |   |   |   |         |             | No. of Hours | Course Objectives |       |
| I                        | Soil Microbiology– Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity, and distribution of major group of microorganisms in soil. Quantification of soil microflora, role of microorganism in soil fertility. Mineralization of Organic & Inorganic matter in soil. Biological nitrogen fixation- Chemistry and Genetics of BNF. |                       |   |   |   |   |         |             | 20           | CO1               |       |
| II                       | Phytopathology and Disease cycle of Plant pathogens - Tikka and Citrus canker, Types of disease symptoms, Structural and Inducible biochemical defenses - Systemic Acquired Resistance (SAR), pathogenesis related (PR) proteins, Plantibodies, Phenolics, Phytoalexins.                                                                                        |                       |   |   |   |   |         |             | 20           | CO2               |       |
| III                      | Interactions among microbial populations- Single microbial populations, positive and negative interactions. Interaction between diverse microbial populations. Population within biofilms. Interaction between microbes and plants – Rhizosphere and mycorrhizae. Interactions with animals – contribution of microbes in animal nutrition and diseases.        |                       |   |   |   |   |         |             | 15           | CO3               |       |
| IV                       | Microbial Communities and Ecosystems – Development of microbial community. Microbial community and dynamics and                                                                                                                                                                                                                                                 |                       |   |   |   |   |         |             | 15           | CO4               |       |

|                  |                                                                                                                                                                                                       |                         |     |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----|
|                  | nature. .Succession within biofilm communities.                                                                                                                                                       |                         |     |
| V                | Quantitative Microbial Ecology – Sample collection, detection of microbial populations, determination of microbial numbers, detecting non culturable bacteria and determination of microbial biomass. | 20                      | CO5 |
|                  | Total                                                                                                                                                                                                 | 90                      |     |
| Course Outcomes  |                                                                                                                                                                                                       |                         |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                          |                         |     |
| CO1              | Depict diversity and significance of soil microbes and predict the role of microbes in biological nitrogen fixation.                                                                                  | PO1                     |     |
| CO2              | Apply the knowledge on plant pathology in agriculture.                                                                                                                                                | PO1, PO7, PO8           |     |
| CO3              | Utilize the knowledge of microbial interactions in various fields.                                                                                                                                    | PO1, PO5, PO6, PO7, PO8 |     |
| CO4              | Predict community ecosystem and their dynamics.                                                                                                                                                       | PO1, PO5                |     |
| CO5              | Apply quantitative microbial ecology for the benefit of mankind.                                                                                                                                      | PO1, PO5                |     |
| Text Books       |                                                                                                                                                                                                       |                         |     |
| 1.               | Subba Rao. N. S. (2017). Soil Microbiology. (5 <sup>th</sup> Edition). MedTech Publishers.                                                                                                            |                         |     |
| 2.               | Rangaswami. G. and Mahadevan. A. (2006). Diseases of Crop Plants in India. (4 <sup>th</sup> Edition). Prentice–Hall of India Pvt. Ltd                                                                 |                         |     |
| 3.               | Larry.L. Barton and Diana .E. Northup. (2011). Microbial Ecology. Wiley Publishers.                                                                                                                   |                         |     |
| 4.               | McArthur. (2006). MicrobialEcology – An Evolutionary Approach AP Publishers.                                                                                                                          |                         |     |
| 5.               | Subba Rao. N.S. (2005). Soil microorganisms and Plant Growth. (4 <sup>th</sup> Edition). Oxford and IBH Publishing Pvt. Ltd.                                                                          |                         |     |
| References Books |                                                                                                                                                                                                       |                         |     |
| 1.               | Bartha .A (2009). Microbial Ecology- Fundamentals and applications. 4 <sup>th</sup> Edn. Pearson Education.                                                                                           |                         |     |
| 2.               | Robert. LTate. (2003).Soil Science – An inter-disciplinary approach to soil research. Lipincott Williams and Wilkins.                                                                                 |                         |     |
| 3.               | Terry J. Gentry and Jeffry. J. Fuhrmann, David A Zuberer. (2021). Principle and application of soil Microbiology. 3 <sup>rd</sup> Edn. Elsilver publications.                                         |                         |     |
| 4.               | Shrivastava A.K. (2003). Environment Auditing. A. P. H. Publishing Corporation.                                                                                                                       |                         |     |
| 5.               | Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan.                                                                   |                         |     |
| Web Resources    |                                                                                                                                                                                                       |                         |     |
| 1.               | <a href="https://staff.oouagoiwoye.edu.ng">https://staff.oouagoiwoye.edu.ng</a>                                                                                                                       |                         |     |
| 2.               | <a href="http://www.scribd.com">http://www.scribd.com</a>                                                                                                                                             |                         |     |
| 3.               | <a href="http://www.environmentshumail.blogspot.in/">www.environmentshumail.blogspot.in/</a>                                                                                                          |                         |     |

|                                   |                                                                                                                 |           |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------|
| 4.                                | <a href="https://www.soinc.org">https://www.soinc.org</a>                                                       |           |
| 5.                                | <a href="https://www.onlinebiologynotes.com">https://www.onlinebiologynotes.com</a>                             |           |
| <b>Methods of Evaluation</b>      |                                                                                                                 |           |
| Internal<br>Evaluation            | Continuous Internal Assessment Tests                                                                            | 25 Marks  |
|                                   | Assignments                                                                                                     |           |
|                                   | Seminars                                                                                                        |           |
|                                   | Attendance and Class Participation                                                                              |           |
| External<br>Evaluation            | End Semester Examination                                                                                        | 75 Marks  |
|                                   | Total                                                                                                           | 100 Marks |
| <b>Methods of Assessment</b>      |                                                                                                                 |           |
| Recall (K1)                       | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |           |
| Understand/<br>Comprehend<br>(K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |           |
| Application<br>(K3)               | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |           |
| Analyse<br>(K4)                   | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |           |
| Evaluate<br>(K5)                  | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |           |
| Create (K6)                       | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |           |

#### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | M    |      |      |      |      |      |      |      |      |       |       |       |       |       |
| CO2 | M    |      |      |      |      |      | M    | M    |      |       |       |       |       |       |
| CO3 | M    |      |      |      | S    | S    | S    | S    |      |       |       |       |       |       |
| CO4 | M    |      |      |      | M    |      |      |      |      |       |       |       |       |       |
| CO5 | M    |      |      |      | M    |      |      |      |      |       |       |       |       |       |

| Subject Code      | Subject Name                                                                                                                                                                                                                                                                                | Category                                                                                                                               | L | T | P | S | Credits | Inst. Hours | Marks         |                   |       |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|---------|-------------|---------------|-------------------|-------|
|                   |                                                                                                                                                                                                                                                                                             |                                                                                                                                        |   |   |   |   |         |             | CIA           | External          | Total |
| 22MBP GE5B        | Microbial Toxicology                                                                                                                                                                                                                                                                        | Elective Course V (Choice 2)                                                                                                           | 3 | 1 | - | - | 3       | 4           | 25            | 75                | 100   |
| Course Objectives |                                                                                                                                                                                                                                                                                             |                                                                                                                                        |   |   |   |   |         |             |               |                   |       |
| CO1               |                                                                                                                                                                                                                                                                                             | Recognize the various categories of environmental toxins and their hazardous consequence                                               |   |   |   |   |         |             |               |                   |       |
| CO2               |                                                                                                                                                                                                                                                                                             | Enhance the knowledge of underlying etiology of bacterial diseases.                                                                    |   |   |   |   |         |             |               |                   |       |
| CO3               |                                                                                                                                                                                                                                                                                             | Promote technical skills for identification of fungal toxins.                                                                          |   |   |   |   |         |             |               |                   |       |
| CO4               |                                                                                                                                                                                                                                                                                             | Gain Knowledge about algal toxins and their effects.                                                                                   |   |   |   |   |         |             |               |                   |       |
| CO5               |                                                                                                                                                                                                                                                                                             | Illustrate various techniques to isolate and characterize the toxin. Examine, interpret and discuss the certainty of toxic substances. |   |   |   |   |         |             |               |                   |       |
| UNIT              | Details                                                                                                                                                                                                                                                                                     |                                                                                                                                        |   |   |   |   |         |             | No. of Hours  | Course Objectives |       |
| I                 | General Introduction - Definition of toxins, different categories of toxins.                                                                                                                                                                                                                |                                                                                                                                        |   |   |   |   |         |             | 12            | CO1               |       |
| II                | Bacterial toxins - Bacterial toxins Bacterial toxinogenesis, endotoxins, exotoxins, exotoxins, bacterial protein toxins with special reference to cholera, diphtheria and tetanus toxins, molecular mechanism of action of endotoxins, exotoxins, enterotoxins, neurotoxins and mycotoxins. |                                                                                                                                        |   |   |   |   |         |             | 12            | CO2               |       |
| III               | Fungal Toxins – Structure, Properties of Aflatoxin, Ochratoxin Patulin, Leukosytrine, Trichothecenes, Fumonisin and Ergot alkaloids.                                                                                                                                                        |                                                                                                                                        |   |   |   |   |         |             | 12            | CO3               |       |
| IV                | Algal Toxins- Structure, Properties of Cyanotoxins- Microcystins, Nodularins, Anatoxin- A, Saxitoxin- Aetokthonotoxin. Others-Hepatotoxin, Neurotoxins, LPS.                                                                                                                                |                                                                                                                                        |   |   |   |   |         |             | 12            | CO4               |       |
| V                 | Tools for isolation and characterization of toxins - Multidimensional chromatographic techniques (gel-filtration, ion-exchange reverse-phase HPLC, SDS-PAGE, 2-dimensional gel electrophoresis).                                                                                            |                                                                                                                                        |   |   |   |   |         |             | 12            | CO5               |       |
|                   | Total                                                                                                                                                                                                                                                                                       |                                                                                                                                        |   |   |   |   |         |             | 60            |                   |       |
| Course Outcomes   |                                                                                                                                                                                                                                                                                             |                                                                                                                                        |   |   |   |   |         |             |               |                   |       |
| Course Outcomes   |                                                                                                                                                                                                                                                                                             | On completion of this course, students will;                                                                                           |   |   |   |   |         |             |               |                   |       |
| CO1               |                                                                                                                                                                                                                                                                                             | Perceive the adverse effects of toxin and its potential                                                                                |   |   |   |   |         |             | PO1, PO2, PO9 |                   |       |

|                         |                                                                                                                                                                                           |                         |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
|                         | role in research.                                                                                                                                                                         |                         |
| CO2                     | Assess the toxicity, properties and mode of actions of bacterial toxins.                                                                                                                  | PO2, PO4, PO6, PO10     |
| CO3                     | Explicate the mode of actions and their biological significance of fungal toxins.                                                                                                         | PO1, PO2, PO4           |
| CO4                     | Evaluate the mode of action and consequences of algal toxins.                                                                                                                             | PO6, PO7. PO9.PO11      |
| CO5                     | Evaluate the toxicity level with the help of advanced techniques.                                                                                                                         | PO4, PO5, PO6, PO8, PO9 |
| <b>Text Books</b>       |                                                                                                                                                                                           |                         |
| 1.                      | Holst O. (2008). Bacterial Toxin –Methods & Protocols. Humana Press.ISBN 9781592590520.                                                                                                   |                         |
| 2.                      | Shier W. T. (1990). Handbook of Toxinology. CRC Press. ISBN 9780824783747.                                                                                                                |                         |
| 3.                      | Wilson K. and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. (7 <sup>th</sup> Edition). Cambridge University Press India Pvt.Ltd. ISBN 1-4051-3544-1. |                         |
| 4.                      | Pholtan Rajeev S.R. (2021)Pictorial handbook for toxinology. Rudra Publications.                                                                                                          |                         |
| 5.                      | Cora Lancaster. (2015). Molecular Toxinology Handbook. Callisto Reference                                                                                                                 |                         |
| <b>References Books</b> |                                                                                                                                                                                           |                         |
| 1.                      | Reilly M. J. (2018). Bioinstrumentation. CBS Publishers and Distributors Pvt Ltd. ISBN 13 978-8123928395.                                                                                 |                         |
| 2.                      | Greenberg M., Hamilton R., Phillips S. and McCluskey G. J. (2003). Occupational, Industrial and Environmental Toxicology. St Louis: C.V. Mosby.                                           |                         |
| 3.                      | Wiley-Vch. (2005). Ullmann's Industrial Toxicology. New York: John Wiley & Sons.                                                                                                          |                         |
| 4.                      | Winder C. and Stacey N.H. and Boca Raton F. L. (2004). Occupational Toxicology. (2 <sup>nd</sup> Edition). CRC Press.                                                                     |                         |
| 5.                      | Gopalakrishnakone(2015). Biological Toxins and Bioterrorism. Springer.                                                                                                                    |                         |
| <b>Web Resources</b>    |                                                                                                                                                                                           |                         |
| 1.                      | <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5869414/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5869414/</a>                                                                 |                         |
| 2.                      | <a href="https://www.reseachgate.net/publication/269037373_TOXIN_AS_A_MEDICINE">https://www.reseachgate.net/publication/269037373_TOXIN_AS_A_MEDICINE</a>                                 |                         |
| 3.                      | <a href="https://www.toxinology.org/">https://www.toxinology.org/</a>                                                                                                                     |                         |
| 4.                      | <a href="https://www.mdpi.com/journal/toxins/special_issues/snakebite_clinical_toxinology">https://www.mdpi.com/journal/toxins/special_issues/snakebite_clinical_toxinology</a>           |                         |

|                                |                                                                                                                 |           |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------|
| 5.                             | <a href="https://pubmed.ncbi.nlm.nih.gov/12807310">https://pubmed.ncbi.nlm.nih.gov/12807310</a>                 |           |
| <b>Methods of Evaluation</b>   |                                                                                                                 |           |
| Internal Evaluation            | Continuous Internal Assessment Tests                                                                            | 25 Marks  |
|                                | Assignments                                                                                                     |           |
|                                | Seminars                                                                                                        |           |
|                                | Attendance and Class Participation                                                                              |           |
| External Evaluation            | End Semester Examination                                                                                        | 75 Marks  |
|                                | Total                                                                                                           | 100 Marks |
| <b>Methods of Assessment</b>   |                                                                                                                 |           |
| Recall (KI)                    | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |           |
| Understand / Comprehended (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |           |
| Application (K3)               | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |           |
| Analyse (K4)                   | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |           |
| Evaluate (K5)                  | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |           |
| Create (K6)                    | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |           |

#### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | S    | S    |      |      |      |      |      |      | S    |       |       |       |       |       |
| CO2 |      | S    |      | S    |      | S    |      |      |      | S     |       |       |       |       |
| CO3 | S    | S    |      | S    |      |      |      |      |      |       |       |       |       |       |
| CO4 |      |      |      |      |      | S    | S    |      | S    |       | S     |       |       |       |
| CO5 |      |      |      | S    | S    | S    |      | S    | S    |       |       |       |       |       |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------|--------------|----------|---|---|---|---|---------|-------------|-------|----------|-------|
|              |              |          |   |   |   |   |         |             | CIA   | External | Total |



|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                             |          |          |          |          |          |          |                         |                              |            |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------|----------|----------|----------|----------|----------|-------------------------|------------------------------|------------|
| <b>22MBP<br/>GE5C</b>    | <b>Water<br/>Conservation<br/>and Water<br/>Treatment<br/>Technologies</b>                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Elective<br/>Course V<br/>(Choice 3)</b> | <b>Y</b> | <b>Y</b> | <b>-</b> | <b>-</b> | <b>3</b> | <b>4</b> | <b>25</b>               | <b>75</b>                    | <b>100</b> |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                             |          |          |          |          |          |          |                         |                              |            |
| CO1                      | Explain how societal and climatic changes will distress water supply and water demand in future                                                                                                                                                                                                                                                                                                                                                                                                |                                             |          |          |          |          |          |          |                         |                              |            |
| CO2                      | Ascertain promising elucidations to the global water crisis and assess the pros and cons                                                                                                                                                                                                                                                                                                                                                                                                       |                                             |          |          |          |          |          |          |                         |                              |            |
| CO3                      | Acquire knowledge to identify the quality of water by standard method                                                                                                                                                                                                                                                                                                                                                                                                                          |                                             |          |          |          |          |          |          |                         |                              |            |
| CO4                      | Illustrate the methods of water treatment technologies and assessing the impact of HWTs                                                                                                                                                                                                                                                                                                                                                                                                        |                                             |          |          |          |          |          |          |                         |                              |            |
| CO5                      | Describe the application and uses of various emerging water treatment technologies                                                                                                                                                                                                                                                                                                                                                                                                             |                                             |          |          |          |          |          |          |                         |                              |            |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                             |          |          |          |          |          |          | <b>No. of<br/>Hours</b> | <b>Course<br/>Objectives</b> |            |
| I                        | Water Scarcity; Major Causes of Water Scarcity, Types of Water Scarcity, Water Footprint- Effects of Water Scarcity Across the Globe-, Water Scarcity in India; Effects of Water Scarcity in India - Social and Political Effects and Economic Risks of Water Scarcity in India.                                                                                                                                                                                                               |                                             |          |          |          |          |          |          | 12                      | CO1                          |            |
| II                       | Multi-pronged approach to Prevent Water Scarcity; Aquifer Recharging, Water reuse and Zero-Liquid Discharge Technology, Coastal Reservoir, Desalination Plants- Measures for Preventing Water Scarcity in India - Jal Shakti Abhiyan Campaign, Atal Bhujal Yojana, Adoption of Composite Water Management Index (CWMI), Water conservation resource management, Rain Water Harvesting.                                                                                                         |                                             |          |          |          |          |          |          | 12                      | CO2                          |            |
| III                      | Water Quality and Pollution; Impurities in the water, Characteristics of different water sources Vulnerability of the water sources to contamination, Water quality criteria - Quality of surface waters, flowing waters, impounded waters, Groundwater, Water quality standards, Microbiological quality of drinking Water, Chemical quality of drinking water.                                                                                                                               |                                             |          |          |          |          |          |          | 12                      | CO3                          |            |
| IV                       | Water Treatment Technologies; Sedimentation, Filtration, Coagulation and flocculation, Water softening and adsorption processes, Membrane filtration, Microfiltration, Ultrafiltration and Nanofiltration, Water disinfection, Activated carbon filtration, Household Water Treatment and Safe Storage (HWTs). Methods for household water treatment Safe water storage, Household water treatment and safe storage decision tree, Assessing the impact of HWTs, Government policies for HWTs. |                                             |          |          |          |          |          |          | 12                      | CO4                          |            |

|                  |                                                                                                                                                                                                                                                                    |                                |     |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-----|
| V                | New and Emerging Drinking Water Treatment Technologies; Nanotechnology, Acoustic nanotube technology, Photocatalytic water purification technology, Aquaporin Inside™ technology, Automatic Variable Filtration (AVF) technology, Sun Spring System, Desalination. | 12                             | CO5 |
|                  | Total                                                                                                                                                                                                                                                              | 60                             |     |
| Course Outcomes  |                                                                                                                                                                                                                                                                    |                                |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                                                                                       |                                |     |
| CO1              | Appraise issues of water scarcity, stress, and conflict on global population.                                                                                                                                                                                      | PO1, PO2, PO4, PO5, PO10       |     |
| CO2              | Apprehend the multiple approaches against water scarcity and to understand various government schemes for water conservation.                                                                                                                                      | PO1, PO2, PO5, PO10, PO14      |     |
| CO3              | Relate the connection between water quality and public health.                                                                                                                                                                                                     | PO4, PO6, PO10                 |     |
| CO4              | Design and execute standard strategy for successful HWTS implementation.                                                                                                                                                                                           | PO4, PO5, PO6, PO9             |     |
| CO5              | Cogitate the purpose, principles, operation, and limitation of various modern water treatment technologies.                                                                                                                                                        | PO5, PO7, PO8, PO9, PO10, PO11 |     |
| Text Books       |                                                                                                                                                                                                                                                                    |                                |     |
| 1.               | Vasileios A., Tzanakakis N. Paranychianakis V. and Angelakis A. N. (2020). Water Supply and Water Scarcity. MDPI, ISBN 978-3-03943-306-3 (Hbk). ISBN 978-3-03943-3070.                                                                                             |                                |     |
| 2.               | Pannirselvam M., Shu Li.,Griffin G., Philip L., Natarajan A. and Hussain S. (2019). Water Scarcity and Ways to Reduce the Impact. ISBN: 978-3-319-75199-3.                                                                                                         |                                |     |
| 3.               | Tiwari A., Kumar A., Singh A., Singh T.N., Suozzi E., Matta G. and Russo S. (2022). Water Scarcity, Contamination and Management. Elsevier. ISBN: 9780323853781.                                                                                                   |                                |     |
| 4.               | Daniel, C.J. (1996). Environmental Aspects of Microbiology, 1 <sup>st</sup> edn. Bright Sun Publications.                                                                                                                                                          |                                |     |
| 5.               | Maier RM, Pepper IL, Gerba CP (2008). Environmental Microbiology, 2 <sup>nd</sup> edn. Academic Press                                                                                                                                                              |                                |     |
| References Books |                                                                                                                                                                                                                                                                    |                                |     |
| 1.               | Fujita K. and Mizushima T. (2021). Sustainable Development in India -Groundwater Irrigation, Energy Use, and Food Production. ISBN 9780367460976.                                                                                                                  |                                |     |
| 2.               | Gupta R. (2008). Water Crisis in India. Atlantic Publishers. ISBN: 9788126909582, 9788126909582.                                                                                                                                                                   |                                |     |

|    |                                                                                                                                                               |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3. | Ahuja S. (2013). Monitoring Water Quality-Pollution Assessment, Analysis, and Remediation. Elsevier. Book ISBN: 9780444594044. Hardcover ISBN: 9780444593955. |
| 4. | Saeid Eslamian ., Faezeh Eslamian ., ( 2021) Water harvesting and conservation – Basic Concepts and fundamentals, Wiley Publications.                         |
| 5. | Buckley RG. (2016) Environmental Microbiology 1 <sup>st</sup> edn. CBS Publishing.                                                                            |

#### Web Resources

|    |                                                                                                                                                                                                         |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | <a href="https://link.springer.com/book/10.1007/978-1-59745-278-6">https://link.springer.com/book/10.1007/978-1-59745-278-6</a>                                                                         |
| 2. | <a href="https://apps.who.int/iris/handle/10665/206916?show=full">https://apps.who.int/iris/handle/10665/206916?show=full</a>                                                                           |
| 3. | <a href="https://www.acs.org/content/acs/en/policy/publicpolicies/sustainability/water-statement.html">https://www.acs.org/content/acs/en/policy/publicpolicies/sustainability/water-statement.html</a> |
| 4. | <a href="https://www.toftigers.org/best-practice/water-conservation-and-treatment/">https://www.toftigers.org/best-practice/water-conservation-and-treatment/</a>                                       |
| 5. | <a href="https://doh.wa.gov/community-and-environment/wastewater-management/site-sewage-systems-oss">https://doh.wa.gov/community-and-environment/wastewater-management/site-sewage-systems-oss</a>     |

#### Methods of Evaluation

|                     |                                      |           |
|---------------------|--------------------------------------|-----------|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks  |
|                     | Assignments                          |           |
|                     | Seminars                             |           |
|                     | Attendance and Class Participation   |           |
| External Evaluation | End Semester Examination             | 75 Marks  |
|                     | Total                                | 100 Marks |

#### Methods of Assessment

|                              |                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

#### Mapping with Programme Outcomes

|     | PO<br>1 | PO<br>2 | PO<br>3 | PO<br>4 | PO<br>5 | PO<br>6 | PO<br>7 | PO<br>8 | PO<br>9 | PO<br>10 | PO<br>11 | PO<br>12 | PO<br>13 | PO<br>14 |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|
| CO1 | S       | S       |         | S       | S       |         |         |         |         | S        |          |          |          |          |
| CO2 | S       | S       |         |         | S       |         |         |         |         | S        |          |          |          | S        |
| CO3 |         |         |         | S       |         | S       |         |         |         | S        |          |          |          |          |
| CO4 |         |         |         | S       | S       | S       |         |         | S       |          |          |          |          |          |
| CO5 |         |         |         |         | S       |         | M       | S       | S       | S        | S        |          |          |          |

| Subject Code             | Subject Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Category        | L | T | P | S | Credits | Inst. Hours | Marks        |                   |       |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---|---|---|---|---------|-------------|--------------|-------------------|-------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |   |   |   |   |         |             | CIA          | External          | Total |
| 22MBP GIM1               | Fermentation technology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Industry Module | 3 | 1 | - | - | 2       | 4           | 25           | 75                | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |   |   |   |   |         |             |              |                   |       |
| CO1                      | Discuss about fermentation and its types, sensitize on methods of strain development for improved yield.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                 |   |   |   |   |         |             |              |                   |       |
| CO2                      | Impart knowledge on the fermenter design and types.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                 |   |   |   |   |         |             |              |                   |       |
| CO3                      | Acquire knowledge on the effective recovery and purification of the products.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                 |   |   |   |   |         |             |              |                   |       |
| CO4                      | Explain the importance of pharmaceutical microbiology.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                 |   |   |   |   |         |             |              |                   |       |
| CO5                      | Illustrate methods for production products using microorganisms and their quality control.                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                 |   |   |   |   |         |             |              |                   |       |
| UNIT                     | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                 |   |   |   |   |         |             | No. of Hours | Course Objectives |       |
| I                        | Bioprocesses - concepts and design. Industrially important microorganisms – Isolation, primary and secondary screening, preservation and improvement of industrially important strains. Upstream processing - Development of inoculums for fermentation process. Media for industrial fermentation - Formulation, optimization. Sterilization. Stages of upstream - Growth of inoculums, fermenter pre-culture and production fermentation. Types of fermentation - Batch, continuous, dual or multiple, surface, submerged, aerobic and anaerobic. |                 |   |   |   |   |         |             | 12           | CO1               |       |
| II                       | Fermenter – Design, types and construction, Instrumentation and control. Productivity. Yield                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                 |   |   |   |   |         |             | 12           | CO2               |       |

|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                         |     |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----|
|                        | coefficients. Heat production. Aeration and agitation. Gas exchange and mass transfer. Computer Applications in fermentation technology. Fermentation Economics.                                                                                                                                                                                                                                                                                                                               |                         |     |
| III                    | Downstream Processing - Recovery and purification of intracellular and extracellular products. Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration - Physical, chemical and enzymatic methods. Extraction - Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization. | 12                      | CO3 |
| IV                     | Overview of pharmaceutical microbiology - Ecology of microorganisms - Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment and their control measures. Design and layout of sterile manufacturing unit. Contamination and Spoilage of Pharmaceutical products - sterile injectable and non-injectable, ophthalmologic preparation, implants.                                                                                                    | 12                      | CO4 |
| V                      | Production of pharmaceutical products and quality assurance – Vaccines, immunodiagnostics, immuno-sera, immunoglobulin. Antibiotics - Penicillin, Griseofulvin, Metronidazole. Enzymes - Streptokinase, Streptodornase. Quality assurance and quality management in pharmaceuticals – In-Process, Final-Product Control and sterility tests. Regulatory aspects - BIS (IS), ISI, ISO, WHO and US certification.                                                                                | 12                      | CO5 |
|                        | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 60                      |     |
| <b>Course Outcomes</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                         |     |
| <b>Course Outcomes</b> | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                         |     |
| CO1                    | Develop microbial strains, carry out fermentation and recover the products of the process.                                                                                                                                                                                                                                                                                                                                                                                                     | PO6, PO7, PO8, PO9      |     |
| CO2                    | Design fermenters according to needs for various products.                                                                                                                                                                                                                                                                                                                                                                                                                                     | PO6, PO7, PO8, PO9      |     |
| CO3                    | Recover the end products of the fermentation process economically.                                                                                                                                                                                                                                                                                                                                                                                                                             | PO4, PO6, PO7, PO8, PO9 |     |
| CO4                    | Utilize the knowledge on pharmaceutical microbiology for industrial production of products.                                                                                                                                                                                                                                                                                                                                                                                                    | PO6, PO7, PO8           |     |
| CO5                    | Produce therapeutic products from microbes employing technology and analyze the quality the products.                                                                                                                                                                                                                                                                                                                                                                                          | PO6, PO7, PO8           |     |
| <b>Text Books</b>      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                         |     |
| 1.                     | Patel A. H. (2016). Industrial Microbiology. (2 <sup>nd</sup> Edition). Laxmi Publications,                                                                                                                                                                                                                                                                                                                                                                                                    |                         |     |

|                              |                                                                                                                                                                                                                             |           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|                              | New Delhi.                                                                                                                                                                                                                  |           |
| 2.                           | Casida L. E. J. R. (2019). Industrial Microbiology. New Age International Publishers.                                                                                                                                       |           |
| 3.                           | Sathyanarayana U. (2005). Biotechnology. (1 <sup>st</sup> Edition). Books and Allied (P) Ltd.                                                                                                                               |           |
| 4.                           | Reed G. (2004). Prescott and Dunn’s Industrial Microbiology. (4 <sup>th</sup> Edition). CBS Publishers & Distributors.                                                                                                      |           |
| 5.                           | Waites M. J., Morgan N. L., Rockey J. S. and Higon G. (2013). Industrial Microbiology: An Introduction. Wiley Blackwell Publishers.                                                                                         |           |
| <b>References Books</b>      |                                                                                                                                                                                                                             |           |
| 1.                           | Stanbury P. T. and Whitaker. (2016). Principles of Fermentation Technology. (3 <sup>rd</sup> Edition). Pergamon Press. NY.                                                                                                  |           |
| 2.                           | Handa S. S. and Kapoor V. K. (2022). Pharamcognosy, (4 <sup>th</sup> Edition). Vallabh Prakashan Publishers, New Delhi.                                                                                                     |           |
| 3.                           | Kokate C. K., Durohit A. P. and Gokhale S. R. Pharmacognosy. (2002). (12 <sup>th</sup> Edition). Nirali Prakasham Publishers, Pune.                                                                                         |           |
| 4.                           | Hugo W. B. and Russell A. D. (2004). Pharmaceutical Microbiology. (7 <sup>th</sup> Edition). Blackwell Scientific Publication, Oxford.                                                                                      |           |
| 5.                           | Wallis, T.E. (2005). Text book of Pharmacognosy. (5 <sup>th</sup> Edition). CBS publishers and distributors, New Delhi.                                                                                                     |           |
| <b>Web Resources</b>         |                                                                                                                                                                                                                             |           |
| 1.                           | <a href="https://ib.bioninja.com.au/options/untitled/b1-microbiology/organisms/fermenters.html">https://ib.bioninja.com.au/options/untitled/b1-microbiology/organisms/fermenters.html</a>                                   |           |
| 2.                           | <a href="https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicillin.html">https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicillin.html</a>                                 |           |
| 3.                           | <a href="https://www.sciencedirect.com/topics/biochemistry-genetics-andmolecular-biology/ethanol-fermentation">https://www.sciencedirect.com/topics/biochemistry-genetics-andmolecular-biology/ethanol-fermentation</a>     |           |
| 4.                           | <a href="https://www.usp.org/sites/default/files/usp/document/harmonization/genmethod/q05b_pf_ira_34_6_2008.pdf">https://www.usp.org/sites/default/files/usp/document/harmonization/genmethod/q05b_pf_ira_34_6_2008.pdf</a> |           |
| 5.                           | <a href="http://www.simbhq.org/">http://www.simbhq.org/</a>                                                                                                                                                                 |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                                                                                             |           |
| <b>Internal Evaluation</b>   | Continuous Internal Assessment Test                                                                                                                                                                                         | 25 Marks  |
|                              | Assignments                                                                                                                                                                                                                 |           |
|                              | Seminars                                                                                                                                                                                                                    |           |
|                              | Attendance and Class Participation                                                                                                                                                                                          |           |
| <b>External Evaluation</b>   | End Semester Examination                                                                                                                                                                                                    | 75 Marks  |
|                              | Total                                                                                                                                                                                                                       | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                                                                                                                             |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                                                                                  |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                                                                              |           |

|                  |                                                                                                                 |
|------------------|-----------------------------------------------------------------------------------------------------------------|
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |
| Analyse (K4)     | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5)    | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)      | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 |      |      |      |      |      | L    | L    | M    | L    |       |       |       |       |       |
| CO2 |      |      |      |      |      | L    | M    | L    | S    |       |       |       |       |       |
| CO3 |      |      |      | M    |      | L    | M    | M    | L    |       |       |       |       |       |
| CO4 |      |      |      |      |      | L    | L    | M    |      |       |       |       |       |       |
| CO5 |      |      |      |      |      | L    | M    | L    |      |       |       |       |       |       |

| Subject Code             | Subject Name                                                                                                                                                                                 | Category                    | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|---|---|---|---|---------|-------------|-------|----------|-------|
|                          |                                                                                                                                                                                              |                             |   |   |   |   |         |             | CIA   | External | Total |
| 22MBP GSEC2              | Organic Farming and Biofertilizer Technology                                                                                                                                                 | Skill Enhancement Course II | 2 | - | - | - | 2       | 2           | 25    | 75       | 100   |
| <b>Course Objectives</b> |                                                                                                                                                                                              |                             |   |   |   |   |         |             |       |          |       |
| CO1                      | Impart knowledge on the importance, types and advantages of organic farming thereby creating awareness on conserving environment and natural resources, encouraging sustainable agriculture. |                             |   |   |   |   |         |             |       |          |       |
| CO2                      | Familiarize with the basic concepts of farm development and relate the development of organic farming in their countries to meet global trends.                                              |                             |   |   |   |   |         |             |       |          |       |
| CO3                      | Explain the various types of biofertilizer and the scope in its production.                                                                                                                  |                             |   |   |   |   |         |             |       |          |       |
| CO4                      | Discuss about biofertilizer production and its field application, promoting economy.                                                                                                         |                             |   |   |   |   |         |             |       |          |       |
| CO5                      | Develop the skill to analyze the quality of packaging, storage, assess the shelf life                                                                                                        |                             |   |   |   |   |         |             |       |          |       |

|                        | and bioefficacy of biofertilizers                                                                                                                                                                                                                                                                                                                                                      |                                                                |                   |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------|
| UNIT                   | Details                                                                                                                                                                                                                                                                                                                                                                                | No. of Hours                                                   | Course Objectives |
| I                      | Organic farming – Definition, relevance. Biological nutrient management - Organic manures, vermicompost, green manure, organic residue, biofertilizer soil amendments. Integrated pest and weed management - Use of biocontrol agents, bio pesticides etc. Organic and Conventional farming. Organic and Chemical farming – Comparison.                                                | 6                                                              | CO1               |
| II                     | Certification and Schemes - Certification and Schemes. Organic certification in brief. Integrated farming system- definition, goal, components. Factors affecting ecological balance. Land degradation. Soil health management. Models of IFS for rainfed and irrigated conditions and different categories of farmers. Government schemes - NPOF, NPOF, NHM, HMNEH, NPMSH&F and RKVY. | 6                                                              | CO2               |
| III                    | Biofertilizers - Introduction, types, advantages and future perspective. Introduction, status and scope. Structure and characteristic features of bacterial biofertilizers- <i>Azospirillum</i> , <i>Azotobacter</i> , <i>Bacillus</i> , <i>Pseudomonas</i> , <i>Rhizobium</i> and <i>Frankia</i> .                                                                                    | 6                                                              | CO3               |
| IV                     | Cyanobacterial biofertilizers- <i>Anabaena</i> , <i>Nostoc</i> , <i>Hapalosiphon</i> and fungal biofertilizers- AM mycorrhiza and ectomycorrhiza. Nitrogen fixation -Free living and symbiotic nitrogen fixation. Mechanism of phosphate solubilization and phosphate mobilization, potassium solubilization.                                                                          | 6                                                              | CO4               |
| V                      | Production technology - Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid bio-fertilizers. FCO specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers. Biofertilizers - Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers. | 6                                                              | CO5               |
|                        | <b>Total</b>                                                                                                                                                                                                                                                                                                                                                                           | <b>30</b>                                                      |                   |
| <b>Course Outcomes</b> |                                                                                                                                                                                                                                                                                                                                                                                        |                                                                |                   |
| <b>Course Outcomes</b> | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                           |                                                                |                   |
| CO1                    | Produce biofertilizers and distinguish between organic and conventional farming.                                                                                                                                                                                                                                                                                                       | PO1, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PO14 |                   |
| CO2                    | Plan a Complete Farm Business including marketing,                                                                                                                                                                                                                                                                                                                                     | PO1, PO2, PO3,                                                 |                   |



|                       |                                                                                                                                                                                                                                             |                                 |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
|                       | operation and financial outline.                                                                                                                                                                                                            | PO4, PO5, PO6, PO7, PO8         |
| CO3                   | Practice the application of microbial bio-fertilizers in large scales, thereby increasing soil fertility.                                                                                                                                   | PO4, PO5, PO6                   |
| CO4                   | Develop integrated farming for sustainable agriculture.                                                                                                                                                                                     | PO6, PO9, PO10                  |
| CO5                   | Promote the quality of packaging, storage, increase shelf life, accelerate the bio efficacy of bio fertilizers as per BIS standards                                                                                                         | PO5, PO7, PO8, PO11, PO13, PO14 |
| Text Books            |                                                                                                                                                                                                                                             |                                 |
| 1.                    | Sharma A. K. (2001). Hand book of Organic Farming. Agrobios.                                                                                                                                                                                |                                 |
| 2.                    | Gaur A. C. (2006). Hand book of Organic Farming and Biofertilizers. Ambika Book Agency.                                                                                                                                                     |                                 |
| 3.                    | Subba Rao N.S. (2017). Bio-fertilizers in Agriculture and Forestry. (4 <sup>th</sup> Edition). Med Tech publisher.                                                                                                                          |                                 |
| 4.                    | Subba Rao N. S. (2002). Soil Microbiology. Soil Microorganisms and Plant Growth. (4 <sup>th</sup> Edition). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.                                                                               |                                 |
| 5.                    | Sathe T.V. (2004). Vermiculture and Organic Farming. Daya Publishers.                                                                                                                                                                       |                                 |
| References Books      |                                                                                                                                                                                                                                             |                                 |
| 1.                    | Rakshit A. and Singh H. B. (2015). ABC of Organic Farming. (1 <sup>st</sup> Edition). Jain Brothers.                                                                                                                                        |                                 |
| 2.                    | Dubey R. C. (2008). A Textbook of Biotechnology. S. Chand & Co., New Delhi.                                                                                                                                                                 |                                 |
| 3.                    | Bansal M. (2019). Basics of Organic Farming. CBS Publisher.                                                                                                                                                                                 |                                 |
| 4.                    | Bhoopander G., Ram Prasad., (2019 ) Biofertilizer for sustainable agriculture and Environment, Springer                                                                                                                                     |                                 |
| 5.                    | Niir Board., ( 2012) (1 <sup>st</sup> Edition ) Biofertiliser and organic farming                                                                                                                                                           |                                 |
| Web Resources         |                                                                                                                                                                                                                                             |                                 |
| 1.                    | <a href="https://agritech.tnau.ac.in/org_farm/orgfarm_introduction.html">https://agritech.tnau.ac.in/org_farm/orgfarm_introduction.html</a>                                                                                                 |                                 |
| 2.                    | <a href="https://www.fao.org/organicag/oa-faq/oa-faq6/en/">https://www.fao.org/organicag/oa-faq/oa-faq6/en/</a>                                                                                                                             |                                 |
| 3.                    | <a href="https://www.india.gov.in/topics/agriculture/organic-farming">https://www.india.gov.in/topics/agriculture/organic-farming</a>                                                                                                       |                                 |
| 4.                    | <a href="https://agriculture.nagaland.gov.in/bio-fertilizer/">https://agriculture.nagaland.gov.in/bio-fertilizer/</a>                                                                                                                       |                                 |
| 5.                    | <a href="https://www.ccd.ngo/sustainable-agriculture.html?gclid=EAIaIQobChMI5a-KndCo-wIV2ZZLBR1ozQj9EAAYAiAAEgJW2_D_BwE">https://www.ccd.ngo/sustainable-agriculture.html?gclid=EAIaIQobChMI5a-KndCo-wIV2ZZLBR1ozQj9EAAYAiAAEgJW2_D_BwE</a> |                                 |
| Methods of Evaluation |                                                                                                                                                                                                                                             |                                 |
| Internal Evaluation   | Continuous Internal Assessment Test                                                                                                                                                                                                         | 25 Marks                        |
|                       | Assignments                                                                                                                                                                                                                                 |                                 |
|                       | Seminars                                                                                                                                                                                                                                    |                                 |

|                                    |                                                                                                                 |           |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------|
|                                    | Attendance and Class Participation                                                                              |           |
| <b>External Evaluation</b>         | End Semester Examination                                                                                        | 75 Marks  |
|                                    | Total                                                                                                           | 100 Marks |
| <b>Methods of Assessment</b>       |                                                                                                                 |           |
| <b>Recall (K1)</b>                 | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |           |
| <b>Understand/ Comprehend (K2)</b> | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |           |
| <b>Application (K3)</b>            | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |           |
| <b>Analyze (K4)</b>                | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |           |
| <b>Evaluate (K5)</b>               | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |           |
| <b>Create (K6)</b>                 | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |           |

#### Mapping with Programme Outcomes

| CO /PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|--------|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1    | S    |      | S    | S    | S    | S    | S    | S    | S    | S     | S     | S     |       | S     |
| CO2    | S    | S    | S    | M    | M    | M    | S    | M    |      |       |       |       |       |       |
| CO3    |      |      |      | S    | S    | S    |      |      |      |       |       |       |       |       |
| CO4    |      |      |      |      |      | M    |      |      | S    | S     |       |       |       |       |
| CO5    |      |      |      |      | M    |      | S    | S    |      |       | S     |       | M     | S     |

#### SECOND YEAR FOURTH SEMESTER

| Subject Code | Subject Name         | Category    | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------|----------------------|-------------|---|---|---|---|---------|-------------|-------|----------|-------|
|              |                      |             |   |   |   |   |         |             | CIA   | External | Total |
| 22MBPGCT 10  | Food and Environment | Core Course | Y | Y | - | - | 4       | 6           | 25    | 75       | 100   |

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                     |  |  |  |  |  |                         |                                   |  |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|--|--|--|--|--|-------------------------|-----------------------------------|--|
|                          | <b>al<br/>Microbiology</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>X<br/>Theory</b> |  |  |  |  |  |                         |                                   |  |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                     |  |  |  |  |  |                         |                                   |  |
| CO1                      | Discuss microorganisms involved in food spoilage.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     |  |  |  |  |  |                         |                                   |  |
| CO2                      | Illustrate bacterial and nonbacterial food borne infections important in public health. Familiarize various national and international aspects of food safety and quality assurance.                                                                                                                                                                                                                                                                                                                                                                                                               |                     |  |  |  |  |  |                         |                                   |  |
| CO3                      | Create awareness. about components of environment, environmental pollution, and detection methods.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                     |  |  |  |  |  |                         |                                   |  |
| CO4                      | Acquire in depth knowledge about solid and liquid waste treatments.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |  |  |  |  |  |                         |                                   |  |
| CO5                      | Develop knowledge about organic matter degradation, bioremediation, and the environment risk assessment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |  |  |  |  |  |                         |                                   |  |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     |  |  |  |  |  | <b>No. of<br/>Hours</b> | <b>Course<br/>Objectiv<br/>es</b> |  |
| I                        | Microorganisms of food- Scope of food Microbiology. Contamination and spoilage of food –vegetables, fruits, poultry, fish, eggs, meat and milk products and canned foods. Food Preservation - Temperature (low and high), drying, radiation and chemicals.                                                                                                                                                                                                                                                                                                                                         |                     |  |  |  |  |  | 18                      | CO1                               |  |
| II                       | Food microbiology and public health. Food hazards. Food Bacterial infections. Nonbacterial food borne illness - Helminthes, nematodes, protozoa, toxigenic fungi and food borne virus. Microbiological quality standards for food. Government regulatory practices and policies - FDA, HACCP, BIS (IS), FSSAI-2014. Food adulteration and common food additives.                                                                                                                                                                                                                                   |                     |  |  |  |  |  | 18                      | CO2                               |  |
| III                      | Components of Environment: Hydrosphere, lithosphere, atmosphere, and biosphere – definitions with examples; Energy flow in the ecosystem- Carbon, Nitrogen, Sulfur and Phosphorous cycles. Physical factors affecting distribution of microorganisms in various environments. Predisposing factors for Environmental diseases – infectious (water and air borne) and pollution related, spread and control of these diseases. Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Space microbiology - Microbiological research in space environment. |                     |  |  |  |  |  | 15                      | CO3                               |  |

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                         |     |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----|
| IV              | Waste management – Solid waste - Types - management - Factors affecting solid waste generation rates. Industrial effluent treatment, primary, secondary, tertiary, and advanced treatment process. Quality assessment of decontaminated matters and other biological effluents. Biological reference standards. Utilization of Solid Waste as Food, Feed and Fuel- Composting, Vermicomposting, Bio manure and Biogas production. E waste management.                                      | 15                      | CO4 |
| V               | Degradation of organic matter - lignin, cellulose, hemicellulose, pectin, common pesticides- herbicides (2,4-D) and pesticides (DDT), heavy metals. Biodegradation of Xenobiotics - Recalcitrant Halocarbons, Recalcitrant TNTs, PCBs and Synthetic polymers. Biodegradation of Hydrocarbons. Biodeterioration of Textiles and Leather. Pollution Control Bodies and Environmental laws in India. Environmental impact assessment, EIA guidelines, US Environment protection Agency norms. | 20                      | CO5 |
|                 | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 90                      |     |
| Course Outcomes |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                         |     |
| Course Outcomes |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                         |     |
| CO1             | Utilize the knowledge on process of food contamination and spoilage to preserve food.                                                                                                                                                                                                                                                                                                                                                                                                      | PO7, PO8, PO9           |     |
| CO2             | Use the knowledge on food borne disease to protect public health.                                                                                                                                                                                                                                                                                                                                                                                                                          | PO5, PO7, PO8, PO9      |     |
| CO3             | Explain the different types of microorganisms in water. Identify the causes of water pollution and the methods for quality assessment of water and control of water borne diseases.                                                                                                                                                                                                                                                                                                        | PO1, PO5, PO6, PO7, PO8 |     |
| CO4             | Apply knowledge about waste treatments and microbial decomposition and bio-remediation process in environmental cleanup.                                                                                                                                                                                                                                                                                                                                                                   | PO1, PO5                |     |
| CO5             | Plan a clear approach on environmental issues. Control pollution and explain protection laws to public.                                                                                                                                                                                                                                                                                                                                                                                    | PO1, PO5                |     |
| Text Books      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                         |     |
| 1.              | Adams M. R. and Moss M. O. (1996). Food Microbiology, New Age International (P) Limited Publishers, New Delhi.                                                                                                                                                                                                                                                                                                                                                                             |                         |     |
| 2.              | Frazier W.C., Westhoff. D. C. and Vanitha K.N. (2013). Food Microbiology. (6 <sup>th</sup> Edition). McGraw Hill Education.                                                                                                                                                                                                                                                                                                                                                                |                         |     |

|                              |                                                                                                                                         |           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 3.                           | Jay J. M., Loessner M. J. and Golden D.A. (2006). Modern Food Microbiology. (7 <sup>th</sup> Edition). Springer.                        |           |
| 4.                           | Shrivastava A.K. (2003). Environment Auditing. A. P. H. Publishing Corporation.                                                         |           |
| 5.                           | Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan.     |           |
|                              | <b>References Books</b>                                                                                                                 |           |
| 1.                           | Robinson R. K. (2000). Dairy Microbiology3 <sup>rd</sup> Edn, Elsevier Applied Science, London.                                         |           |
| 2.                           | Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7 <sup>th</sup> Edn. Edward Arnold: London.                         |           |
| 3.                           | Banwarst. G.J. (2003). Basic Food Microbiology 2 <sup>nd</sup> Edn, CBS Publishers and distributors.                                    |           |
| 4.                           | Bitton, G. (2011). Wastewater Microbiology. (4 <sup>th</sup> Edition). Wiley-Blackwell.                                                 |           |
| 5.                           | Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association.                |           |
| <b>Web Resources</b>         |                                                                                                                                         |           |
| 1.                           | <a href="https://www.fssai.gov.in">https://www.fssai.gov.in</a>                                                                         |           |
| 2.                           | <a href="https://www.who.int/news-room/fact-sheets/detail/food-safety">https://www.who.int/news-room/fact-sheets/detail/food-safety</a> |           |
| 3.                           | <a href="https://egyankosh.ac.in">https://egyankosh.ac.in</a>                                                                           |           |
| <b>Methods of Evaluation</b> |                                                                                                                                         |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                    | 25 Marks  |
|                              | Assignments                                                                                                                             |           |
|                              | Seminars                                                                                                                                |           |
|                              | Attendance and Class Participation                                                                                                      |           |
| External Evaluation          | End Semester Examination                                                                                                                | 75 Marks  |
|                              | Total                                                                                                                                   | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                                         |           |
| Recall (KI)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                              |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                          |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                  |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge                         |           |

|               |                                                                                          |
|---------------|------------------------------------------------------------------------------------------|
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons                   |
| Create (K6)   | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

#### Mapping with Programme Outcomes

|     | PO<br>1 | PO<br>2 | PO<br>3 | PO<br>4 | PO<br>5 | PO<br>6 | PO<br>7 | PO<br>8 | PO<br>9 | PO<br>10 | PO<br>11 | PO<br>12 | PO<br>13 | PO<br>14 |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|
| CO1 |         |         |         |         |         |         | S       | M       | M       |          |          |          |          |          |
| CO2 |         |         |         |         | S       |         | M       | M       | M       |          |          |          |          |          |
| CO3 |         |         |         | S       |         |         | M       | M       |         |          |          |          |          |          |
| CO4 |         |         |         |         |         |         | M       | M       |         |          |          |          |          |          |
| CO5 |         |         |         |         |         |         | M       | M       |         |          |          |          |          |          |

| Subject Code             | Subject Name                                                   | Category              | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------------------|----------------------------------------------------------------|-----------------------|---|---|---|---|---------|-------------|-------|----------|-------|
|                          |                                                                |                       |   |   |   |   |         |             | CIA   | External | Total |
| 22MBPG CT11              | Research Methodology and Biostatistics                         | Core Course XI Theory | Y | Y | - | - | 4       | 6           | 25    | 75       | 100   |
| <b>Course Objectives</b> |                                                                |                       |   |   |   |   |         |             |       |          |       |
| CO1                      | Discuss the methods and techniques of data collection.         |                       |   |   |   |   |         |             |       |          |       |
| CO2                      | Explain sampling methods, write research reports and articles. |                       |   |   |   |   |         |             |       |          |       |
| CO3                      | Discuss the basic concepts of Biostatistics.                   |                       |   |   |   |   |         |             |       |          |       |
| CO4                      | Describe statistical software for analysis.                    |                       |   |   |   |   |         |             |       |          |       |
| CO5                      | Explain the tests of significance.                             |                       |   |   |   |   |         |             |       |          |       |

| UNIT                   | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                    | No. of Hours | Course Objectives |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------------------|
| I                      | Introduction to Research Methodology - Meaning and importance. Statement, Constraints. Review of literature - Review and synopsis presentation. Types of research, Research tools. Methods and techniques of data collection - types of data, methods of primary data collection (observation/ experimentation/ questionnaire/ interviewing/ case/pilot study, methods), methods of secondary data collection.                                             | 20           | CO1               |
| II                     | Sampling and sampling distributions. Sampling frame, importance of probability sampling, sampling - simple random, systematic, stratified random and cluster. Variables - nominal, ordinal, discontinuous, continuous, derived. Research process, designs and Report writing - types of research reports, guidelines for writing an article and report, report format, appendices, Ethical issues related to publishing, Plagiarism and Self-Plagiarism.   | 20           | CO2               |
| III                    | Introduction to Biostatistics - Basic concepts, Measurement and measurement scales, Sampling and data collection, Data presentation. Measures of central tendency: Mean, Median, Mode. Measures of variability - Standard deviation, standard error, range, mean deviation and coefficient of variation. Frequency table of single discrete variable, bubble plot, computation of mean, variance and standard Deviations, t test, correlation coefficient. | 15           | CO3               |
| IV                     | Correlation and regression - Positive, negative, calculation of Karl-Pearsons co-efficient of correlation. Linear regression and multiple linear regression, ANOVA, one and two way classification. Calculation of an unknown variable using regression equation. Tests of significance - Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error.                                             | 20           | CO4               |
| V                      | Probability and distributions - Introduction to probability theory and distributions, (concept without deviation) binomial, poisson and normal (only definitions and problems) Computer oriented statistical techniques. RSM: methods for process optimization set up CCD, Box Behnken, optimal RSM design, regression models FDS curves, surface contours, multi linear constraints and categorical factors to optimal design.                            | 15           | CO5               |
|                        | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 90           |                   |
| <b>Course Outcomes</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                            |              |                   |
| <b>Course Outcomes</b> | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                               |              |                   |

|                  |                                                                                                                                                                                                                                                                                                               |                                               |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| CO1              | Collect and present data suitable to the research design.                                                                                                                                                                                                                                                     | PO1, PO4, PO9, PO10                           |
| CO2              | Write research manuscripts and articles for journals.                                                                                                                                                                                                                                                         | PO1, PO2, PO3, PO4, PO5, PO6, PO9, PO10, PO13 |
| CO3              | Recommend the utilization of biostatistics tools for analysis of biological data.                                                                                                                                                                                                                             | PO5, PO6, PO9, PO10, PO13                     |
| CO4              | Prove and justify hypothesis for a particular research.                                                                                                                                                                                                                                                       | PO3, PO4, PO9, PO10                           |
| CO5              | Apply software tools for interpretation of biological data.                                                                                                                                                                                                                                                   | PO4, PO9, PO10, PO13                          |
| Text Books       |                                                                                                                                                                                                                                                                                                               |                                               |
| 1.               | Sharma K. R. (2002) Research methodology. National Publishing House, New Delhi.                                                                                                                                                                                                                               |                                               |
| 2.               | Daniel W.W. (2005). Biostatistics; A foundation for analysis in the health sciences. (7 <sup>th</sup> Edition). Jhon Wiley & sons Inc, New York.                                                                                                                                                              |                                               |
| 3.               | Rao P. S. S. and Richard J. (2006). Introduction to Biostatistics & Research methods. Prentice-Hall, New Delhi.                                                                                                                                                                                               |                                               |
| 4.               | Veerakumari L. (2015) Bioinstrumentation 1 <sup>st</sup> edn. MJP Publishers.                                                                                                                                                                                                                                 |                                               |
| 5.               | Ahuja V.K. (2017) Laws Relating to Intellectual Property Rights. Lexis Nexis.                                                                                                                                                                                                                                 |                                               |
| References Books |                                                                                                                                                                                                                                                                                                               |                                               |
| 1.               | Zar J. H. (2006). Biostatistical Analysis. (4 <sup>th</sup> Edition). Pearson Education Inc. New Jersey.                                                                                                                                                                                                      |                                               |
| 2.               | Beins B. C. and McCarthy M.A. (2011). Research Methods and Statistics. Pearson Education Inc. New Jersey.                                                                                                                                                                                                     |                                               |
| 3.               | Adams K. A. and Lawrence E. M. K. (2014). Research Methods, Statistics, and Applications. SAGE Publications, Inc., New Delhi.                                                                                                                                                                                 |                                               |
| 4.               | Anderson J.B. and Poole M. (2011). Assignment and Thesis Writing. 4 <sup>th</sup> edn. Wiley India Private Limited.                                                                                                                                                                                           |                                               |
| 5.               | Kothari C.R. and Garg G (2004) Research Methodology: Methods and Techniques. 2 <sup>nd</sup> Edition. New Age International Publishers                                                                                                                                                                        |                                               |
| Web Resources    |                                                                                                                                                                                                                                                                                                               |                                               |
| 1.               | <a href="https://www.studocu.com/en-ca/document/mount-royal-university/quantitative-research-methods-and-data-analysis/lecture-notes-all-lectures/344093">https://www.studocu.com/en-ca/document/mount-royal-university/quantitative-research-methods-and-data-analysis/lecture-notes-all-lectures/344093</a> |                                               |
| 2.               | <a href="https://www.khanacademy.org/math/statistics-probability/sampling-distributions-library">https://www.khanacademy.org/math/statistics-probability/sampling-distributions-library</a>                                                                                                                   |                                               |
| 3.               | <a href="https://testbook.com/learn/maths-mean-median-mode/">https://testbook.com/learn/maths-mean-median-mode/</a>                                                                                                                                                                                           |                                               |
| 4.               | <a href="https://rcub.ac.in/econtent/ug/bcom/sem4/Business%20Statistics%20Unit%204%2">https://rcub.ac.in/econtent/ug/bcom/sem4/Business%20Statistics%20Unit%204%2</a>                                                                                                                                         |                                               |



|                       |                                                                                                                                                                                                       |           |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|                       | 0Correlation%20and%20Regression.pdf                                                                                                                                                                   |           |
| 5.                    | <a href="https://www.cse.iitk.ac.in/users/piyush/courses/pml_fall17/material/probabilty_tutorial.pdf">https://www.cse.iitk.ac.in/users/piyush/courses/pml_fall17/material/probabilty_tutorial.pdf</a> |           |
| Methods of Evaluation |                                                                                                                                                                                                       |           |
| Internal Evaluation   | Continuous Internal Assessment Tests                                                                                                                                                                  | 25 Marks  |
|                       | Assignments                                                                                                                                                                                           |           |
|                       | Seminars                                                                                                                                                                                              |           |
|                       | Attendance and Class Participitation                                                                                                                                                                  |           |
| External Evaluation   | End Semester Examination                                                                                                                                                                              | 75 Marks  |
|                       | Total                                                                                                                                                                                                 | 100 Marks |

| Methods of Assessment        |                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

#### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | L    |      |      | L    |      |      |      |      | L    | L     |       |       |       |       |
| CO2 | M    | M    | M    | M    | M    | M    |      |      | M    | M     |       |       | M     |       |
| CO3 |      |      |      |      | S    | S    |      |      | S    | S     |       |       | S     |       |
| CO4 |      |      | S    | S    |      |      |      |      | S    | S     |       |       |       |       |
| CO5 |      |      |      | M    |      |      |      |      | M    | M     |       |       | M     |       |

| Subject | Subject | Category | L | T | P | S | Credits | Inst. | Marks |
|---------|---------|----------|---|---|---|---|---------|-------|-------|
|---------|---------|----------|---|---|---|---|---------|-------|-------|

| Code              | Name                                                                                                                                                                                                                                                                                                                                           |                               |   |   |   |   |   | Hours | CIA             | External             | Total |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---|---|---|---|---|-------|-----------------|----------------------|-------|
| 22MBP<br>GCP4     | Practical<br>IV –<br>Applied<br>Microbiology                                                                                                                                                                                                                                                                                                   | Core Course<br>XII Practicals | - | - | 6 | - | 4 | 6     | 40              | 60                   | 100   |
| Course Objectives |                                                                                                                                                                                                                                                                                                                                                |                               |   |   |   |   |   |       |                 |                      |       |
| CO1               | Enumerate bacteria in milk for quality analysis.                                                                                                                                                                                                                                                                                               |                               |   |   |   |   |   |       |                 |                      |       |
| CO2               | Analyze methods for microbes from spoiled food .                                                                                                                                                                                                                                                                                               |                               |   |   |   |   |   |       |                 |                      |       |
| CO3               | Gain knowledge on microbes present in water.                                                                                                                                                                                                                                                                                                   |                               |   |   |   |   |   |       |                 |                      |       |
| CO4               | Identification and characterization of nitrogen fixers.                                                                                                                                                                                                                                                                                        |                               |   |   |   |   |   |       |                 |                      |       |
| CO5               | Gain knowledge on biofertilizer production.and field application.                                                                                                                                                                                                                                                                              |                               |   |   |   |   |   |       |                 |                      |       |
| UNIT              | Details                                                                                                                                                                                                                                                                                                                                        |                               |   |   |   |   |   |       | No.<br>of Hours | Course<br>Objectives |       |
| I                 | Breed count, Direct microscopic count and Standard plate count of Milk, Methylene blue reductase test, Resazurin test and alkaline phosphatase test of milk.                                                                                                                                                                                   |                               |   |   |   |   |   |       | 20              | CO1                  |       |
| II                | Isolation of bacteria, fungi and yeast from spoiled and canned food. Production and detection of aflatoxins from spoiled food.                                                                                                                                                                                                                 |                               |   |   |   |   |   |       | 20              | CO2                  |       |
| III               | Microbial Analysis of water – MPN, Membrane filtration. Chemical - BOD.                                                                                                                                                                                                                                                                        |                               |   |   |   |   |   |       | 10              | CO3                  |       |
| IV                | Enumeration of bacteria and fungi from air – Air sampler<br>Isolation of free-living nitrogen fixers from soil and <i>Rhizobium</i> from root nodules of leguminous plants.<br>Isolation and enumeration of phosphate-solubilizing bacteria from soil                                                                                          |                               |   |   |   |   |   |       | 20              | CO4                  |       |
| V                 | Preparation of Biofertilizers and testing the efficiency of prepared biofertilizers, R:S ratio of soil microbes<br>Study of phylloplane microflora by leaf impression method<br>Isolation of cellulose degrading bacteria<br>Isolation of plant pathogen – <i>Alternaria</i> , <i>Curvularia</i> ,<br>Cultivation of mushroom from solid waste |                               |   |   |   |   |   |       | 20              | CO5                  |       |
|                   | Total                                                                                                                                                                                                                                                                                                                                          |                               |   |   |   |   |   |       | 90              |                      |       |
| Course Outcomes   |                                                                                                                                                                                                                                                                                                                                                |                               |   |   |   |   |   |       |                 |                      |       |
| Course Outcomes   | On completion of this course, students will;                                                                                                                                                                                                                                                                                                   |                               |   |   |   |   |   |       |                 |                      |       |
| CO1               | Check the quality of milk                                                                                                                                                                                                                                                                                                                      |                               |   |   |   |   |   |       | PO7, PO10       |                      |       |
| CO2               | Identify bacteria and fungi in spoiled food                                                                                                                                                                                                                                                                                                    |                               |   |   |   |   |   |       | PO5, PO7, PO10  |                      |       |

|                     |                                                                                                                                                                                                    |           |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| CO3                 | Analyze potability of water                                                                                                                                                                        | PO5, PO10 |
| CO4                 | Check the microbial population in air.                                                                                                                                                             | PO5, PO10 |
| CO5                 | Prepare, apply and check the efficiency of biofertilizers.                                                                                                                                         | PO5, PO10 |
| Text Books          |                                                                                                                                                                                                    |           |
| 1.                  | Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5 <sup>th</sup> Edition). CRC Press.                                                                                              |           |
| 2.                  | Garg N., Garg K. and Mukerji K. G. (2013). I K. International Pvt. Ltd.                                                                                                                            |           |
| 3.                  | Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2 <sup>nd</sup> Edition). Academic Press, Elsevier.                                                |           |
| 4.                  | Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4 <sup>th</sup> Edition). Wiley.                                                             |           |
| 5.                  | Adams M.R, and Moss M.D, (2005). Food Microbiology 4 <sup>th</sup> Edition, New Age International Pvt. Ltd., Publishers.First edition.                                                             |           |
|                     | References Books.                                                                                                                                                                                  |           |
| 1.                  | Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7 <sup>th</sup> Edition Edward Arnold: London.                                                                                 |           |
| 2.                  | Vijaya R K, (2004). Food Microbiology 1 <sup>st</sup> Edition. MJP Publishers, Chennai.                                                                                                            |           |
| 3.                  | Banwarst. G.J. (2003). Basic Food Microbiology 2 <sup>nd</sup> Edition, CBS Publishers and distributors.                                                                                           |           |
| 4.                  | James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5 <sup>th</sup> Edition). The Benjamin publishing company. New York.                                          |           |
| 5.                  | Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). Manual of Environmental Microbiology. (3 <sup>rd</sup> Edition). American Society for Microbiology. |           |
|                     | Web Resources                                                                                                                                                                                      |           |
| 1.                  | <a href="https://www.fssai.gov.in">https://www.fssai.gov.in</a>                                                                                                                                    |           |
| 2.                  | <a href="https://www.who.int/news-room/fact-sheets/detail/food-safety">https://www.who.int/news-room/fact-sheets/detail/food-safety</a>                                                            |           |
| 3.                  | <a href="https://academic.oup.com/bioscience/article/65/8/758/240222">https://academic.oup.com/bioscience/article/65/8/758/240222</a>                                                              |           |
| 4.                  | <a href="https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5">https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5</a>                                      |           |
| 5.                  | <a href="https://vlab.amrita.edu/index.php?sub=3&amp;brch=272">https://vlab.amrita.edu/index.php?sub=3&amp;brch=272</a>                                                                            |           |
|                     | Methods of Evaluation                                                                                                                                                                              |           |
| Internal Evaluation | Continuous Internal Assessment Tests                                                                                                                                                               | 40 Marks  |
|                     | Assignments                                                                                                                                                                                        |           |
|                     | Seminars                                                                                                                                                                                           |           |
|                     | Attendance and Class Participation                                                                                                                                                                 |           |

|                              |                                                                                                                 |           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------|
| External Evaluation          | End Semester Examination                                                                                        | 60 Marks  |
|                              | Total                                                                                                           | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                 |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |           |

### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 |      |      |      |      |      |      | M    |      |      | M     |       |       |       |       |
| CO2 |      |      |      |      | S    |      | M    |      |      | M     |       |       |       |       |
| CO3 |      |      |      |      | L    |      |      |      |      | M     |       |       |       |       |
| CO4 |      |      |      |      | M    |      |      |      |      | M     |       |       |       |       |
| CO5 |      |      |      |      | M    |      |      |      |      | M     |       |       |       |       |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------|--------------|----------|---|---|---|---|---------|-------------|-------|----------|-------|
|              |              |          |   |   |   |   |         |             | CIA   | External | Total |
| 22MBP        | Bioenergy    | Elective | Y | Y | - | - | 3       | 4           | 25    | 75       | 100   |

|                   |                                                                                                                                                                                                                                                                                                                                                                 |                         |  |  |  |  |  |                 |                      |  |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|--|--|--|--|--|-----------------|----------------------|--|
| GE6A              |                                                                                                                                                                                                                                                                                                                                                                 | Course VI<br>(Choice 1) |  |  |  |  |  |                 |                      |  |
| Course Objectives |                                                                                                                                                                                                                                                                                                                                                                 |                         |  |  |  |  |  |                 |                      |  |
| CO1               | Acquire knowledge on bioenergy utilizing organic wastes for energy recovery.                                                                                                                                                                                                                                                                                    |                         |  |  |  |  |  |                 |                      |  |
| CO2               | Discuss methods and strategies of exploiting microbes for the production technology of biodiesel.                                                                                                                                                                                                                                                               |                         |  |  |  |  |  |                 |                      |  |
| CO3               | Describe resources and techniques for the production and estimation of eco-friendly biofuels and the extent of their use potentially.                                                                                                                                                                                                                           |                         |  |  |  |  |  |                 |                      |  |
| CO4               | Gain knowledge for executing biogas plant in communities.                                                                                                                                                                                                                                                                                                       |                         |  |  |  |  |  |                 |                      |  |
| CO5               | Explain possibility of using microbes for the production of bio-hydrogen as a source of future fuel.                                                                                                                                                                                                                                                            |                         |  |  |  |  |  |                 |                      |  |
| UNIT              | Details                                                                                                                                                                                                                                                                                                                                                         |                         |  |  |  |  |  | No. of<br>Hours | Course<br>Objectives |  |
| I                 | Bioenergy – Biomass Energy Resources. Biomass conversion methods. Microbes as bioresources for bioenergy products (Bacteria, fungi, yeast and microalgae) - Bioprospecting of microbial strains for biofuel production.                                                                                                                                         |                         |  |  |  |  |  | 12              | CO1                  |  |
| II                | Biodiesel – Microbes and Biodiesel. Production and feed stock. Techniques of lipid extraction and conversion to biodiesel. Biodiesel quality and its assessment. Strategies of genetic engineering of organisms for biodiesel production. Biodiesel production from single cell organisms ( <i>Cryptococcus</i> , <i>Cunninghamella</i> , <i>Mortierella</i> ). |                         |  |  |  |  |  | 12              | CO2                  |  |
| III               | Alcoholic Fuels from microorganisms: Biochemical conversion to ethanol: Biomass pre-treatment, Starch to sucrose conversion and Sucrose to ethanol fermentation. Role of enzymes and their applications in ethanol production. Distillation and Quantification of ethanol. Production and Estimation of biobutanol, biomethanol, biopropanol and bioglycerol.   |                         |  |  |  |  |  | 12              | CO3                  |  |
| IV                | Biogas - Microbes and Biogas production, Biogas plants – types – design – construction– Biogas Bottling Technology and Development in India, Biogas appliances – burner, luminaries and power generation – effect on engine performance. Application of Biogas slurry in agriculture.                                                                           |                         |  |  |  |  |  | 12              | CO4                  |  |
| V                 | Biohydrogen– Production from bacteria and algae. Commercialized microalgae ( <i>Spirulina</i> , <i>Dunaliella</i> , <i>Hematococcus</i> and <i>Chlorella</i> ) and their production. Economics of microalgae production. Cultivation of seaweeds. Microbial fuel cells.                                                                                         |                         |  |  |  |  |  | 12              | CO5                  |  |
|                   | Total                                                                                                                                                                                                                                                                                                                                                           |                         |  |  |  |  |  | 60              |                      |  |
| Course Outcomes   |                                                                                                                                                                                                                                                                                                                                                                 |                         |  |  |  |  |  |                 |                      |  |
| Course            | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                    |                         |  |  |  |  |  |                 |                      |  |

| Outcomes         |                                                                                                                                                                                                                                                                     |                      |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| CO1              | Evaluate the various aspects of biomass production and their implementation.                                                                                                                                                                                        | PO1, PO5, PO6        |
| CO2              | Design and construct a biodiesel plant.                                                                                                                                                                                                                             | PO5, PO7, PO8, PO11, |
| CO3              | Carry out the process of fermentation for bio – alcohol fuels.                                                                                                                                                                                                      | PO1, PO4, PO5, PO7,  |
| CO4              | Identify the nature of biogas as a biofuel and their technologies and applications.                                                                                                                                                                                 | PO5, PO7, PO8, PO11. |
| CO5              | Design, execute and extract biohydrogen from algae.                                                                                                                                                                                                                 | PO4, PO5, PO7, PO8.  |
| Text Books       |                                                                                                                                                                                                                                                                     |                      |
| 1.               | Dahiya A. (2014). Bioenergy- Biomass to Biofuel. (1 <sup>st</sup> Edition). Academic Press Editor.                                                                                                                                                                  |                      |
| 2.               | Brown R. C. (2003). Biorenewable Resources: Engineering New Products from Agriculture. (1 <sup>st</sup> Edition). Wiley Blackwell Publishing.                                                                                                                       |                      |
| 3.               | Jawaid M., Hakeem K. R. and Rashid U. (2014). Biomass and Bioenergy: Processing and Properties. (1 <sup>st</sup> Edition). Springer Cham.                                                                                                                           |                      |
| 4.               | Caye M. Drapcho, Tery H. Walker (Biofuels EngineeringProcess Technology. McGraw Hill.                                                                                                                                                                               |                      |
| 5.               | Teri. Bio energy Powering the Future. Pearson Longman Publications.                                                                                                                                                                                                 |                      |
| References Books |                                                                                                                                                                                                                                                                     |                      |
| 1.               | Konur O. (2018). Bioenergy and Biofuels. (1 <sup>st</sup> Edition). CRC Press.                                                                                                                                                                                      |                      |
| 2.               | Lee J. W.(2012). Advanced Biofuels and Bioproducts. (13 <sup>th</sup> Edition), Springer.                                                                                                                                                                           |                      |
| 3.               | Khanal S. (2008). Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. (8 <sup>th</sup> Edition). Wiley-Blackwell Publishing.                                                                                                             |                      |
| 4.               | Pradeep Chaturvedi.(1995). Bioenergy Resources. Concept Publishing Company.                                                                                                                                                                                         |                      |
| 5.               | Lee S. (2018).Biofuel and Bioenergy. Taylor and Francis                                                                                                                                                                                                             |                      |
| Web Resources    |                                                                                                                                                                                                                                                                     |                      |
| 1.               | <a href="https://www.elsevier.com">https://www.elsevier.com</a> Biofuels and Bioenergy                                                                                                                                                                              |                      |
| 2.               | <a href="https://www.sciencedirect.com">https://www.sciencedirect.com</a> › book › bioenergy                                                                                                                                                                        |                      |
| 3.               | <a href="https://www.un.org/en/climatechange/what-is-renewable-energy?gclid=EAIaIQobChMIqriN2Nao-wIV2HwrCh2pfA5mEAAYASAAEgI-p_D_BwE">https://www.un.org/en/climatechange/what-is-renewable-energy?gclid=EAIaIQobChMIqriN2Nao-wIV2HwrCh2pfA5mEAAYASAAEgI-p_D_BwE</a> |                      |
| 4.               | <a href="https://www.energy.gov/eere/bioenergy/bioenergy-basics">https://www.energy.gov/eere/bioenergy/bioenergy-basics</a>                                                                                                                                         |                      |
| 5.               | <a href="https://www.iea.org/fuels-and-technologies/bioenergy">https://www.iea.org/fuels-and-technologies/bioenergy</a>                                                                                                                                             |                      |

| <b>Methods of Evaluation</b> |                                      |          |
|------------------------------|--------------------------------------|----------|
| Internal Evaluation          | Continuous Internal Assessment Tests | 25 Marks |
|                              | Assignments                          |          |
|                              | Seminars                             |          |
|                              | Attendance and Class Participation   |          |

|                              |                                                                                                                 |           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------|
| External Evaluation          | End Semester Examination                                                                                        | 75 Marks  |
|                              | Total                                                                                                           | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                 |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |           |

#### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | M    |      |      |      | S    | S    |      |      |      |       |       |       |       |       |
| CO2 |      |      |      |      | S    |      | S    | S    |      |       | S     |       |       |       |
| CO3 | M    |      |      | S    | S    |      | S    |      |      |       |       |       |       |       |
| CO4 |      |      |      |      | S    |      | S    | S    |      |       | S     |       |       |       |
| CO5 |      |      |      | S    | S    |      | S    | S    |      |       |       |       |       |       |

| Subject Code | Subject Name        | Category           | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------|---------------------|--------------------|---|---|---|---|---------|-------------|-------|----------|-------|
|              |                     |                    |   |   |   |   |         |             | CIA   | External | Total |
| 22MBP GE6B   | Marine Microbiology | Elective Course VI | 3 | 1 | - | - | 4       | 4           | 25    | 75       | 100   |

|                   |                                                                                                                                                                                                                                                                                                                        |            |  |  |  |  |  |              |                   |  |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|--|--|--|--|--|--------------|-------------------|--|
|                   |                                                                                                                                                                                                                                                                                                                        | (Choice 2) |  |  |  |  |  |              |                   |  |
| Course Objectives |                                                                                                                                                                                                                                                                                                                        |            |  |  |  |  |  |              |                   |  |
| CO1               | Gain fundamental knowledge of marine environment and the microbial communities inhabiting the oceans.                                                                                                                                                                                                                  |            |  |  |  |  |  |              |                   |  |
| CO2               | Discuss the metabolic diversity of marine microorganisms and their interrelationships.                                                                                                                                                                                                                                 |            |  |  |  |  |  |              |                   |  |
| CO3               | Explain the survival of microorganisms in extreme environments.                                                                                                                                                                                                                                                        |            |  |  |  |  |  |              |                   |  |
| CO4               | Illustrate pathogens and contaminants in sea foods.                                                                                                                                                                                                                                                                    |            |  |  |  |  |  |              |                   |  |
| CO5               | Describe the applications of marine biotechnological products and their future role in a rapidly changing planet.                                                                                                                                                                                                      |            |  |  |  |  |  |              |                   |  |
| UNIT              | Details                                                                                                                                                                                                                                                                                                                |            |  |  |  |  |  | No. of Hours | Course Objectives |  |
| I                 | Marine microbial environment - Benthic & littoral zone, salt pan, mangroves and estuarine microbes, microbial loop. Marine microbial communities – Bacteria, fungi, protozoa. Microbial interactions – Endosymbionts and Ectosymbionts.                                                                                |            |  |  |  |  |  | 12           | CO1               |  |
| II                | Dynamics of Marine Microbes - Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming – Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization – phosphorus cycle. Decomposition of organic matter. Bioleaching and biodeterioration of natural and synthetic materials. |            |  |  |  |  |  | 12           | CO2               |  |
| III               | Marine extremophiles: Mechanism of survival at extreme environments – Adaptive mechanisms in thermophilic, alkalophilic, osmophilic, barophilic, psychrophilic hyperthermophilic and halophilic microorganisms – Importance in biotechnology.                                                                          |            |  |  |  |  |  | 12           | CO3               |  |
| IV                | Marine Microbial Diseases: Aqua culture pathogens & Water borne pathogens - <i>Aeromonas</i> , <i>Vibrio</i> , <i>Salmonella</i> , <i>Pseudomonas</i> , <i>Leptospira</i> , <i>Corynebacteria</i> and viral diseases. Rapid diagnosis of contamination in sea foods and aquaculture products.                          |            |  |  |  |  |  | 12           | CO4               |  |
| V                 | Applications of Marine Microbial Biotechnology: Production and applications of marine microbial products – Enzymes, Antibiotics, Organic acids, Toxins, Biosurfactants and Pigments. Sea food preservation methods. Probiotic bacteria and their importance in aquaculture.                                            |            |  |  |  |  |  | 12           | CO5               |  |
|                   | Total                                                                                                                                                                                                                                                                                                                  |            |  |  |  |  |  | 60           |                   |  |
| Course Outcomes   |                                                                                                                                                                                                                                                                                                                        |            |  |  |  |  |  |              |                   |  |
| Course Outcomes   | On completion of this course, students will;                                                                                                                                                                                                                                                                           |            |  |  |  |  |  |              |                   |  |
| CO1               | Apply the knowledge on marine microbial communities and their interactions.                                                                                                                                                                                                                                            |            |  |  |  |  |  |              | PO1, PO9          |  |
| CO2               | Illustrate the role of marine microorganisms in biogeochemical                                                                                                                                                                                                                                                         |            |  |  |  |  |  |              | PO5, PO7          |  |



|                              |                                                                                                                                                                                                     |               |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
|                              | cycles.                                                                                                                                                                                             |               |
| CO3                          | Categorize the extreme environments in the oceans and the survival mechanisms adapted by the microorganisms living in these environments.                                                           | PO7, PO9      |
| CO4                          | Identify the diseases affecting marine organisms and its diagnosis.                                                                                                                                 | PO5, PO7      |
| CO5                          | Evaluate the marine microorganisms as a resource for novel microbial products.                                                                                                                      | PO7, PO8, PO9 |
| <b>Text Books</b>            |                                                                                                                                                                                                     |               |
| 1.                           | Munn C. B. (2019). Marine Microbiology: Ecology and Applications. (3 <sup>rd</sup> Edition). CRC Press. ISBN:9780367183561.                                                                         |               |
| 2.                           | Bhakuni, D.S. and Rawat D. S. (2005). Bioactive Marine Natural Products. Anamaya Publishers, New Delhi. ISBN:1-4020-3472-5.                                                                         |               |
| 3.                           | Brock T. D. (2011). Thermophilic Microorganisms and Life at High Temperatures. Springer. ISBN-13:978-1461262862 / ISBN-10:1461262860.                                                               |               |
| 4.                           | Nybakken, J.W. (2001). Marine Biology. (5 <sup>th</sup> Edition). Benjamin Cummings. ISBN:0321030761 9780321030764.                                                                                 |               |
| 5.                           | Veena. (Understanding marine biology. Discovery Publishing.                                                                                                                                         |               |
| <b>References Books</b>      |                                                                                                                                                                                                     |               |
| 1.                           | Maier R. M., Pepper I. L. and Gerba C. P. (2006). Environmental Microbiology. (2 <sup>nd</sup> Edition). Academic Press. ISBN:978-0-12-370519-8.                                                    |               |
| 2.                           | Belkin S. and Colwell R. R. (2005). Oceans and Health: Pathogens in the Marine Environment. Springer. ISBN:978-0-387-23708-4.                                                                       |               |
| 3.                           | Scheper T. (2009). Advances in Biochemical Engineering/Biotechnology-Marine Biotechnology. Springer. ISBN:978-3-540-69356-7. E-ISBN:978-3-540-69357-4.                                              |               |
| 4.                           | Gasol J. M. and Kirchman D. L. (Eds.). (2018). Microbial Ecology of the Oceans. (3 <sup>rd</sup> Edition). Wiley-Blackwell. ISBN:978-1-119-10718-7.                                                 |               |
| 5.                           | Kim S. K. (2019). Essentials of Marine Biotechnology. Springer.                                                                                                                                     |               |
| <b>Web Resources</b>         |                                                                                                                                                                                                     |               |
| 1.                           | <a href="https://link.springer.com/content/pdf/bfm%3A978-0-387-23709-1%2F1">https://link.springer.com/content/pdf/bfm%3A978-0-387-23709-1%2F1</a>                                                   |               |
| 2.                           | <a href="https://www.researchgate.net/publication/285931262_Bioactive_Marine_Natural_Products">https://www.researchgate.net/publication/285931262_Bioactive_Marine_Natural_Products</a>             |               |
| 3.                           | <a href="http://link.springer.com/content/pdf/bfm%3A978-3-642-03470-1%2F1.pdf">http://link.springer.com/content/pdf/bfm%3A978-3-642-03470-1%2F1.pdf</a>                                             |               |
| 4.                           | <a href="https://link.springer.com/book/10.1007/b102184">https://link.springer.com/book/10.1007/b102184</a>                                                                                         |               |
| 5.                           | <a href="https://www.wiley.com/en-bs/Microbial+Ecology+of+the+Oceans%2C+3rd+Edition-p-9781119107187">https://www.wiley.com/en-bs/Microbial+Ecology+of+the+Oceans%2C+3rd+Edition-p-9781119107187</a> |               |
| <b>Methods of Evaluation</b> |                                                                                                                                                                                                     |               |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                                                | 25 Marks      |
|                              | Assignments                                                                                                                                                                                         |               |
|                              | Seminars                                                                                                                                                                                            |               |

|                              |                                                                                                                 |           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------|
|                              | Attendance and Class Participation                                                                              |           |
| External Evaluation          | End Semester Examination                                                                                        | 75 Marks  |
|                              | Total                                                                                                           | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                 |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |           |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |           |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |           |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |           |

#### Mapping with Programme Outcomes

|     | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| CO1 | M    |      |      |      |      |      |      |      | M    |       |       |       |       |       |
| CO2 |      |      |      |      | M    |      | S    |      |      |       |       |       |       |       |
| CO3 |      |      |      |      |      |      | M    |      | S    |       |       |       |       |       |
| CO4 |      |      |      |      | M    |      | S    |      |      |       |       |       |       |       |
| CO5 |      |      |      |      |      |      | S    | S    | M    |       |       |       |       |       |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------|--------------|----------|---|---|---|---|---------|-------------|-------|----------|-------|
|              |              |          |   |   |   |   |         |             | CIA   | External | Total |

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                           |   |   |   |   |   |   |                         |                              |     |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|---|---|---|---|---|---|-------------------------|------------------------------|-----|
| 22MBP<br>GE6C            | Life Sciences<br>for<br>Competitive<br>Examinations                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Elective<br>Course<br>VI<br>(Choice<br>3) | 3 | 1 | - | - | 3 | 4 | 25                      | 75                           | 100 |
| <b>Course Objectives</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                           |   |   |   |   |   |   |                         |                              |     |
| CO1                      | Impart knowledge on structure, metabolism and function of biomolecules.                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                           |   |   |   |   |   |   |                         |                              |     |
| CO2                      | Understand the importance of inheritance biology.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                           |   |   |   |   |   |   |                         |                              |     |
| CO3                      | Discuss in-depth about the different types of ecosystems and their importance.                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                           |   |   |   |   |   |   |                         |                              |     |
| CO4                      | Outline the major drivers in biodiversity and various conservation approaches.                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                           |   |   |   |   |   |   |                         |                              |     |
| CO5                      | Introduce basic concepts of evolution and biological clock.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                           |   |   |   |   |   |   |                         |                              |     |
| <b>UNIT</b>              | <b>Details</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                           |   |   |   |   |   |   | <b>No. of<br/>Hours</b> | <b>Course<br/>Objectives</b> |     |
| I                        | Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins. Structure of atoms, molecules and chemical bonds. Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). Bioenergetics.                                                                                  |                                           |   |   |   |   |   |   | 12                      | CO1                          |     |
| II                       | Cellular Organisation, Cell division and cell cycle, Membrane structure and function, Organization of genes and chromosomes, Structural organization and function of intracellular organelles, DNA replication, repair and recombination, Protein synthesis and processing.                                                                                                                                                                                                                                                   |                                           |   |   |   |   |   |   | 12                      | CO2                          |     |
| III                      | Inheritance Biology, Mendelian principles- Dominance, segregation, independent assortment, Linkage and Gene mapping, Karyotyping, Extrachromosomal inheritance - Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Human genetics-Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.                                                                                                                                                                                    |                                           |   |   |   |   |   |   | 12                      | CO3                          |     |
| IV                       | Ecology- Habitat and Niche, biotic and abiotic interactions, Biome- biogeographical zones of India. Ecological Succession, Population Ecology- Characteristics of a population; population growth curves, Environmental pollution-global environmental change, Biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Biodiversity Management approaches. Indian case studies on Conservation/Management strategy (Project Tiger, Biosphere Reserves). |                                           |   |   |   |   |   |   | 12                      | CO4                          |     |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |               |     |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----|
| V                | Evolution and Behaviour- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological, Embryological and Molecular evidences. Hardy Weinberg's Law. Speciation; Allopatricity and Sympatricity. Adaptive radiation and Convergent evolution; Sexual selection; Co-evolution. Altruism, Biological clocks, Migration and Parental care. Molecular Evolution- Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny. | 12            | CO5 |
|                  | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 60            |     |
| Course Outcomes  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |               |     |
| Course Outcomes  | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                                      |               |     |
| CO1              | Define, classify and assess the structure, biological functions and interactions of Biomolecules.                                                                                                                                                                                                                                                                                                                                                                                 | PO4, PO6, PO9 |     |
| CO2              | Validate the knowledge of collective and progressive notions of cellular organization.                                                                                                                                                                                                                                                                                                                                                                                            | PO4, PO6, PO9 |     |
| CO3              | Assess and describe the importance of inheritance biology.                                                                                                                                                                                                                                                                                                                                                                                                                        | PO4, PO6, PO9 |     |
| CO4              | Establish acquaintance and understanding of ecology & Biodiversity in a broader sense.                                                                                                                                                                                                                                                                                                                                                                                            | PO4, PO6, PO9 |     |
| CO5              | Understand the processes of evolution, relate with natural selection, adaptation and speciation.                                                                                                                                                                                                                                                                                                                                                                                  | PO4, PO6, PO9 |     |
| Text Books       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |               |     |
| 1.               | Nelson D. L. and Cox M. M. (2008). Lehningers Principles of Biochemistry. (5 <sup>th</sup> Edition). W.H. Freeman and Company.                                                                                                                                                                                                                                                                                                                                                    |               |     |
| 2.               | Chapman J. L. (1998).Ecology: Principles and Applications. (2 <sup>nd</sup> Edition). Cambridge University Press.                                                                                                                                                                                                                                                                                                                                                                 |               |     |
| 3.               | Krishnamurthy V. K. (2003). Textbook of Biodiversity. Science Publishers.                                                                                                                                                                                                                                                                                                                                                                                                         |               |     |
| 4.               | Rogers A. L. (2011). Evidence of Evolution. University of Chicago Press. Chicago.                                                                                                                                                                                                                                                                                                                                                                                                 |               |     |
| 5.               | Stites D.P.,Abba I.Terr, Parslow T.G.(1997). <u>Medical Immunology</u> . 9 <sup>th</sup> Edn, Prentice-Hall Inc.                                                                                                                                                                                                                                                                                                                                                                  |               |     |
| References Books |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |               |     |
| 1.               | Pontarotti P. (2018). Origin and Evolution of biodiversity. (1 <sup>st</sup> Edition). Springer.                                                                                                                                                                                                                                                                                                                                                                                  |               |     |
| 2.               | Verma P. S. and Agarwal V. K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2 <sup>nd</sup> Edition). S Chand publication.                                                                                                                                                                                                                                                                                                                           |               |     |
| 3.               | Lewin R. and Foley R. (2004). Principles of Human Evolution. (2 <sup>nd</sup> Edition). Black well Publishing Company.                                                                                                                                                                                                                                                                                                                                                            |               |     |
| 4.               | Boyer R.F. (2002) <u>Modern Experimental Biochemistry</u> 3 <sup>rd</sup> Edition. Pearson Education.                                                                                                                                                                                                                                                                                                                                                                             |               |     |

|    |                                                                                                                                                                                                     |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5. | Wilson K., Walker J., Clokie S and Hofmann A. (2018) <u>Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology</u> 8 <sup>th</sup> Edition Cambridge University Press. |
|    |                                                                                                                                                                                                     |

#### Web Resources

|    |                                                                                                                                                                                                                                             |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | <a href="https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_">https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_</a>                                                                       |
| 2. | <a href="https://www.livescience.com/474-controversy-evolution-works.html">https://www.livescience.com/474-controversy-evolution-works.html</a> .                                                                                           |
| 3. | <a href="https://www.examrace.com/Study-Material/Life-Sciences/">https://www.examrace.com/Study-Material/Life-Sciences/</a>                                                                                                                 |
| 4. | <a href="https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR-NET-Exam-by-Panel-Of-Experts">https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR-NET-Exam-by-Panel-Of-Experts</a> |
| 5  | <a href="https://www.erforum.net/2017/01/life-science-biology-handwritten-notes-for-competitive-exams.html">https://www.erforum.net/2017/01/life-science-biology-handwritten-notes-for-competitive-exams.html</a>                           |

#### Methods of Evaluation

|                     |                                      |           |
|---------------------|--------------------------------------|-----------|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks  |
|                     | Assignments                          |           |
|                     | Seminars                             |           |
|                     | Attendance and Class Participation   |           |
| External Evaluation | End Semester Examination             | 75 Marks  |
|                     | Total                                | 100 Marks |

#### Methods of Assessment

|                              |                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                      |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                  |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                          |
| Analyse (K4)                 | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5)                | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)                  | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

#### Mapping with Programme Outcomes

|  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|--|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|  | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO |
|  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 |

|     |   |  |  |   |   |   |  |  |   |   |  |  |  |  |
|-----|---|--|--|---|---|---|--|--|---|---|--|--|--|--|
| CO1 | L |  |  | S | L | S |  |  | S | M |  |  |  |  |
| CO2 | L |  |  | S | L | S |  |  | S | M |  |  |  |  |
| CO3 | L |  |  | S | L | S |  |  | S | M |  |  |  |  |
| CO4 | L |  |  | S | L | S |  |  | S | M |  |  |  |  |
| CO5 | L |  |  | S | L | S |  |  | S | M |  |  |  |  |

| Subject Code      | Subject Name                  | Category | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|-------------------|-------------------------------|----------|---|---|---|---|---------|-------------|-------|----------|-------|
|                   |                               |          |   |   |   |   |         |             | CIA   | External | Total |
| <b>22PGM BPRO</b> | <b>Project with Viva voce</b> |          | - | - | 4 | - | 4       | 4           | 40    | 60       | 100   |

## OBJECTIVES OF THE COURSE

To impart advanced practical knowledge to conduct a research project. To plan and design statistically, retrieve relevant literature, organize and conduct, process the data, photograph relevant observations, evaluate by statistical programmes. Present the project in any regional/national conference/seminar during the second year of the course and submit for final semester examinations. The work has to be conducted in department under the guidance of the project supervisor. Interdisciplinary collaborations from external departments / institutions can be organized only for essential areas of the project. Industrial visit has been included along with the project work as a report (minimum of 10 pages) possibly with geo-tagged photographs. The method of valuation of the project and Industrial visit report submitted by the candidate is outlined as follows:

Internal (2 out of 3 presentations)      -      25 Marks

Viva      -      15 Marks

| Subject Code             | Subject Name                                                                                                 | Category                     | L | T | P | S | Credits | Inst. Hours | Marks |          |       |
|--------------------------|--------------------------------------------------------------------------------------------------------------|------------------------------|---|---|---|---|---------|-------------|-------|----------|-------|
|                          |                                                                                                              |                              |   |   |   |   |         |             | CIA   | External | Total |
| 22MBP GSEC3              | Microbial Quality Control and Testing                                                                        | Skill Enhancement Course III | Y | - | - | - | 2       | 2           | 25    | 75       | 100   |
| <b>Course Objectives</b> |                                                                                                              |                              |   |   |   |   |         |             |       |          |       |
| CO1                      | Explain various microbiological quality standards for food, water and air regulatory practices and policies. |                              |   |   |   |   |         |             |       |          |       |
| CO2                      | Discuss collection, processing and preservation of water samples from industries in different areas.         |                              |   |   |   |   |         |             |       |          |       |
| CO3                      | Enumeration and isolation of microorganism from the water samples.                                           |                              |   |   |   |   |         |             |       |          |       |
| CO4                      | Enumeration and isolation of microorganism from the air samples.                                             |                              |   |   |   |   |         |             |       |          |       |
| CO5                      | Gain knowledge on sterility testing of different components in industries and quality control techniques.    |                              |   |   |   |   |         |             |       |          |       |

| UNIT | Details                                                                                                                                                                                                                                                                                                                                                                                                 | No. of Hours | Course Objectives |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------------------|
| I    | Concepts of quality control techniques - quality assurance, Total Quality Management (TQM) Continuous Quality Improvement (CQI) Quality Assurance (QA) pre analytical and post analytical techniques, ATCC, MTCC, microbial based assay.                                                                                                                                                                | 6            | CO1               |
| II   | Waste water microbiology – types and sources of contamination, prevention of water borne diseases. Water management, water harvesting, water recycling. Characteristics of waste water from industries - Sugar factory, Pulp & Paper mill, Distillery, Textile, Engineering, Food Industry, Domestic waste. Waste water treatment plant types and quality control. Water pollution causes and remedies. | 6            | CO2               |
| III  | Microflora of water. Microbiological analysis of water sample. Microbiological analysis of water sample collection, drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative                                                                                                                                                                                   | 6            | CO3               |

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                    |     |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----|
|                 | procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests Control of microbes in water: Water borne pathogens, water borne diseases. Control of water borne pathogens - Precipitation, chemical disinfection, filtration, high temperature, UV light.                                                                                                                           |                    |     |
| IV              | Microflora of air - Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres. Collection of air samples and analysis. Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, isolation and Identification. Control Measures of Bioaerosols - UV light, HEPA filters, desiccation, Incineration. | 6                  | CO4 |
| V               | Quality control in food - Food X ray inspection, PPE Equipment, IoT sensors, preventive quality control and reality quality control. Quality control of pharma products. Quality assurance framework, assessment of pharmaceutical quality, determinants of pharmaceutical quality, practical approaches to quality assurance.                                                                                                                                          | 6                  | CO5 |
|                 | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 30                 |     |
| Course Outcomes |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                    |     |
| Course Outcomes | On completion of this course, students will;                                                                                                                                                                                                                                                                                                                                                                                                                            |                    |     |
| CO1             | Apply knowledge in quality analysis techniques suitable for industries.                                                                                                                                                                                                                                                                                                                                                                                                 | PO4, PO5, PO7, PO8 |     |
| CO2             | Perform water managements, water harvesting and treat sewage, water pollutions and remedies.                                                                                                                                                                                                                                                                                                                                                                            | PO4, PO5, PO7, PO8 |     |
| CO3             | Detect portability of water. Test water quality.                                                                                                                                                                                                                                                                                                                                                                                                                        | PO4, PO5, PO7, PO8 |     |
| CO4             | Impart knowledge on bioaerosols, impact and prevention                                                                                                                                                                                                                                                                                                                                                                                                                  | PO4, PO5, PO7, PO8 |     |
| CO5             | Apply quality control techniques for food and pharma products                                                                                                                                                                                                                                                                                                                                                                                                           | PO4, PO5, PO7, PO8 |     |
| Text Books      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                    |     |
| 1.              | Aneja R. P., Mathur B.N., Chandan R. C. and Banerjee, A. K. (2002). Experiments in Microbiology.                                                                                                                                                                                                                                                                                                                                                                        |                    |     |
| 2.              | Adams M. R. and Moss M. O. (2006). Food Microbiology. (2 <sup>nd</sup> Edition). Royal Society of Chemistry.                                                                                                                                                                                                                                                                                                                                                            |                    |     |
| 3.              | Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand.                                                                                                                                                                                                                                                                                                                                                                                               |                    |     |



|                              |                                                                                                                                                                                                                                           |           |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 4.                           | Cappuccino, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6 <sup>th</sup> Edition). Pearson Education, Publication, New Delhi.                                                                                           |           |
| 5.                           | Rosamund M. Baird., Norman A. (2019). Handbook of Microbiological quality control in Pharmaceuticals and Medical Devices. CRC Press.                                                                                                      |           |
| <b>References Books</b>      |                                                                                                                                                                                                                                           |           |
| 1.                           | Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2 <sup>nd</sup> Edition). - Taylor & Francis.                                                                                                                      |           |
| 2.                           | Sundararaj T. (2003). Microbiology Laboratory Manual. (2 <sup>nd</sup> Edition). Published by A. Sundararaj                                                                                                                               |           |
| 3.                           | Hoges N. A., Denyer S P. and Baird R.M. (2003). Handbook of microbiological quality control. Microbial Quality Assurance in Pharmaceutcals, cosmetics & Toiletries. by Sally F. Bloomfield                                                |           |
| 4.                           | Amitava Mitra. Fundamentals of Quality control and Improvement. (3 <sup>rd</sup> Edition). Wiley Publications                                                                                                                             |           |
| 5.                           | David Roesti, Marcel Goverde (2019). Pharmaceutical Microbiological Quality Assurance and control: Practical guide for non- sterile Manufacturing. Wiley Publishers.                                                                      |           |
| <b>Web Resources</b>         |                                                                                                                                                                                                                                           |           |
| 1.                           | <a href="https://www.researchgate.net/publication/320730681">https://www.researchgate.net/publication/320730681</a>                                                                                                                       |           |
| 2.                           | <a href="https://www.fssai.gov.in">https://www.fssai.gov.in</a>                                                                                                                                                                           |           |
| 3.                           | <a href="https://mofpi.nic.in/Schemes/implementation-haccp-iso-22000-iso-9000-ghp-gmp-etc">https://mofpi.nic.in/Schemes/implementation-haccp-iso-22000-iso-9000-ghp-gmp-etc</a>                                                           |           |
| 4.                           | <a href="https://www.who.int/news-room/fact-sheets/detail/food-safety">https://www.who.int/news-room/fact-sheets/detail/food-safety</a>                                                                                                   |           |
| 5.                           | <a href="https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines">https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines</a> |           |
| <b>Methods of Evaluation</b> |                                                                                                                                                                                                                                           |           |
| Internal Evaluation          | Continuous Internal Assessment Tests                                                                                                                                                                                                      | 25 Marks  |
|                              | Assignments                                                                                                                                                                                                                               |           |
|                              | Seminars                                                                                                                                                                                                                                  |           |
|                              | Attendance and Class Participitation                                                                                                                                                                                                      |           |
| External Evaluation          | End Semester Examination                                                                                                                                                                                                                  | 75 Marks  |
|                              | Total                                                                                                                                                                                                                                     | 100 Marks |
| <b>Methods of Assessment</b> |                                                                                                                                                                                                                                           |           |
| Recall (K1)                  | Simple definitions, MCQ, Recall steps, Concept definitions                                                                                                                                                                                |           |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview                                                                                                                                                            |           |
| Application (K3)             | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain                                                                                                                                                    |           |

|               |                                                                                                                 |
|---------------|-----------------------------------------------------------------------------------------------------------------|
| Analyse (K4)  | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons                                          |
| Create (K6)   | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations                        |

### Mapping with Programme Outcomes

|     | PO<br>1 | PO<br>2 | PO<br>3 | PO<br>4 | PO<br>5 | PO<br>6 | PO<br>7 | PO<br>8 | PO<br>9 | PO<br>10 | PO<br>11 | PO<br>12 | PO<br>13 | PO<br>14 |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|
| CO1 |         |         |         | M       | L       |         | S       | S       |         |          |          |          |          |          |
| CO2 |         |         |         | M       | L       |         | M       | M       |         |          |          |          |          |          |
| CO3 |         |         |         | S       | L       |         | S       | S       |         |          |          |          |          |          |
| CO4 |         |         |         | S       | L       |         | S       | S       |         |          |          |          |          |          |
| CO5 |         |         |         | S       | L       |         | M       | M       |         |          |          |          |          |          |

