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SHIVAJI UNIVERSITY, KOLHAPUR - 416004, MAHARASHTRA
PHONE:EPABX-2609000, www.unishivaji.ac.in, bos@unishivaji.ac.in
शिवाजी विद्यापीठ, कोल्हापूर -४१६००४,महाराष्ट्र
दूरध्वनी-ईपीएबीएक्स -२६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१—२६०९०९४
०२३१—२६०९४८७

**Ref.No.SU/BOS/Science/434** **Date: 15/07/2025**

**To,**

The Principal,
All Concerned Affiliated Colleges/Institutions
Shivaji University, Kolhapur.

**Subject:** Regarding revised syllabi of B.Sc. Part-II (Sem.III & IV) degree programme under the Faculty of Science and Technology as per NEP-2020 (2.0)

**Ref:** No.SU/BOS/Science/270 & 271 Date: 03/05/2025 Letter.

**Sir/Madam,**

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the syllabi, nature of question paper of B.Sc. Part-II (Sem.III & IV ) degree programme under the Faculty of Science and Technology as per NEP-2020 (2.0).

| B.Sc.Part-II (Sem. III & IV ) as per NEP-2020 (2.0) | | | |
|---|---|---|---|
| 1. | Botany | 8. | Geology |
| 2. | Statistics | 9. | Zoology |
| 3. | Mathematics | 10. | Chemistry |
| 4. | Microbiology | 11. | Electronics |
| 5. | Plant Protection | 12. | Industrial Microbiology |
| 6. | B.A./B.A.B.Ed. Geography | 13. | Biotechnology(Voc/Opt) |
| 7. | Biotechnology(Entire) | | |

This syllabus, nature of question and equivalence shall be implemented from the academic year 2025-2026 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website www.unishivaji.ac.in NEP-2020@suk(Online Syllabus)

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October /November 2025 & March/April 2026. These chances are available for repeater students, if any.

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

**Dy Registrar**
**Dr. S. M. Kubal**

**Encl: As above**

**for Information and necessary action**

**Copy to:**

| | | | |
|---|---|---|---|
| 1 | Dean, Faculty of Science & Technology | 6 | Appointment Section A & B |
| 2 | Director, Board of Examinations and Evaluation | 7 | I.T.Cell /Computer Centre |
| 3 | Chairman, Respective Board of Studies | 8 | Eligibility Section |
| 4 | B.Sc.-M.Sc. Exam Section | 9 | Affiliation Section (T.1) (T.2) |
| 5 | Internal Quality Assurance Cell (IQAC Cell) | 10 | P.G. Seminar Section |

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०२३१—२६०९४८७

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**Ref.No.SU/BOS/Science/270** **Date: 03/05/2025**

**To,**

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| B.Sc.Part-II (Sem. III & IV ) as per NEP-2020 (2.0) | | | |
|---|---|---|---|
| 1. | Botany | 8. | Geology |
| 2. | Physics | 9. | Zoology |
| 3. | Statistics | 10. | Chemistry |
| 4. | Mathematics | 11. | Electronics |
| 5. | Microbiology | 12. | Drug Chemistry |
| 6. | Plant Protection | 13. | Industrial Microbiology |
| 7. | Astrophysics and Space Science | 14. | Sugar Technology (Entire) |

This syllabus, nature of question and equivalence shall be implemented from the academic year 2025-2026 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website www.unishivaji.ac.in NEP-2020@suk(Online Syllabus)

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You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

**Yours faithfully,**

**By Registrar**
**Dr. S. M. Kubal**

**Encl: As above**

**for Information and necessary action**

**Copy to:**

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# SHIVAJI UNIVERSITY, KOLHAPUR.

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**Structure and Syllabus in Accordance with**

**National Education Policy - 2020 (NEP 2.0)**

**with Multiple Entry and Multiple Exit**

**Syllabus For**

**B.Sc. Part II**

## INDUSTRIAL MICROBIOLOGY

**(Faculty of Science and Technology)**

**MAJOR COURSE**

**SEMESTER III AND IV**

**(To Be Implemented from Academic Year 2025-26)**

1. **Year of Implementation:** Revised Syllabus will be implemented from June, 2025 onwards.

2. **Preamble:**

This syllabus is framed to give sound knowledge with understanding of Industrial Microbiology to undergraduate students at second year of three years of B.Sc. degree course. The goal of the syllabus is to make the study of Industrial Microbiology popular, interesting and encouraging to the students for higher studies including research. The new and updated syllabus is based on a basic and applied approach with vigour and depth. At the same time, precaution is taken to make the syllabus comparable to the syllabi of other universities and the needs of industries and research. The syllabus is prepared after discussion at length with number of faculty members of the subject and experts from industries and research fields. The units of the syllabus are well defined, taking into consideration the level and capacity of students.

| **3. Program Learning Outcomes (PLOs):** | |
|---|---|
| A candidate who wishes to graduate in B.Sc. (Industrial Microbiology Course) needs to have acquired/developed following competencies: | |
| 1 | Acquired knowledge and understanding of the industrial microbiology concepts as applicable to diverse areas such as medical, industrial, environment, genetics, agriculture, food and others. |
| 2 | Demonstrate key practical skills/competencies in working with microbes for study and use in the laboratory as well as outside, including the use of good microbiological practices. |
| 3 | Competent enough to use industrial microbiology knowledge and skills to analyze problems involving microbes, articulate these with peers/ team members/ other stake holders, and undertake remedial measures/studies etc. |
| 4 | Developed a broader perspective of the discipline of industrial microbiology to enable him to identify challenging societal problems and plan his professional career to develop innovative solutions for such problems. |

| 4. Course Outcomes (COs) | |
|---|---|
| **Course V: INDUSTRIAL FERMENTED FOODS PRODUCTION, SPOILAGE AND ITS PRESERVATION** | |
| 1 | Understand the industrial production processes of fermented dairy products, alcoholic beverages, and pickles |
| 2 | Learn the types and causes of spoilage in fermented dairy products, alcoholic beverages, and pickles |
| 3 | Identify spoilage organisms and their effects on product quality and safety |
| 4 | Explore preservation methods used for dairy products, alcoholic beverages, and pickles |
| **Couse VI: QUALITY CONTROL AND ASSURANCE OF FOOD PRODUCTS** | |
| 1 | Learn microbiological tests to check food quality and detect pathogens. |
| 2 | Understand food quality regulations like PFA, FDA, FPO, ISO, BIS, and AGMARK. |
| 3 | Learn the basics of GMP, GLP, and HACCP for food safety. |
| 4 | Apply TQM and ICMSF guidelines in milk and food quality control |
| **Course VII: FERMENTATION TECHNOLOGY** | |
| 1 | Understand the industrial production process of antibiotics and organic acids |
| 2 | Identify raw materials and microbes used in fermentation for pharmaceutical products |
| 3 | Learn the steps of recovery and applications of amino acids and enzymes |
| 4 | Explore the role of fermentation in producing valuable bio-products like antibiotics, acids, and enzymes |
| **Course VIII: INDUSTRIAL PRODUCTION OF BIOFERTILIZERS** | |
| 1 | Understand the role and need of nitrogen-fixing biofertilizers in organic farming |
| 2 | Learn the characteristics, production, and application of Rhizobium, Azotobacter, and Azospirillum biofertilizers |
| 3 | Study the types, functions, and application methods of VAM and PSB biofertilizers |
| 4 | Understand FCO guidelines for quality control, sampling, and standards of biofertilizers |

| 5. Program Objectives (POs): | |
|---|---|
| 1 | To create a centre of Academic Excellence in the field of education in Industrial Microbiology. |
| 2 | To provide a sound academic background for overall development of personality for a successful career in Industrial Microbiology. |
| 3 | To provide an environment that fosters continuous improvement and innovation in the subject. |
| 4 | To instill in student the essential skills oriented towards self-development. |
| 5 | To inculcate in students the need for the value of dignity of labour, the positive attitude and proper community orientation and civic responsibilities in their outlook. |
| 6 | To cultivate a sense of social responsibility in students, encouraging them to be active citizens through an excellent academic program and participation in daily management tasks. |

**6. Duration of the Program:** The course shall be a full-time course.

**7. Medium of Instruction:** The medium of instruction shall be English.

**8. Eligibility for Admission:** The criterion for admission is as per the rules and regulations set from time to time by concerned departments, HEIs, university, government, and other relevant statutory authorities.

**9. Scheme of Teaching and Examination Pattern (Theory/Practical/Internal):**

The scheme of teaching and examination for a program of study as approved by the Academic Council / Board of Studies.

Each theory course is of 2 credits and require 30 hours of teaching. There shall be two lectures per theory course per week. Each practical course is of 2 credits and require 60 hours of teaching.

The pattern of examination will be Semester End Examination with Internal Assessment/Evaluation. Note: Separate passing is mandatory for both, Semester End Examination and Internal Assessment/ Evaluation.

**10. Equivalence of the papers:**

Two additional chances shall be provided for the repeater students of old three-year B.Sc. immediate after their Semester VI or VIII. After that the students concerned shall have to appear for the Examination as per this revised pattern. Equivalence of papers shall be provided as per revised syllabus for the pattern in accordance with NEP.

## 11. Programme Structure

| SHIVAJIUNIVERSITY, KOLHAPUR<br>NEP-2020 (2.0): Credit Framework for UG (B. Sc. II) Programme under Faculty of Science and Technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SEM (Level) | COURSES | | OE | VSC/SEC | AEC/VEC/IKS | OJT/FP/CEP /CC/RP | Total Credits | Degree/Cum. Cr. MEME |
| | MAJOR | MINOR | | | | | | |
| SEMIII (5.0) | Major V (2)<br>Major VI (2)<br>Major P III (2) | Minor V (2)<br>Minor VI (2)<br>Minor P III (2) | OE-3(2) (T/P) | VSC I (2) (P)<br>(Major specific)<br>SEC I (2) (T/P) | AEC I (2)<br>(English) | CC-I (2) | 22 | UG Diploma 88 |
| SEMIV (5.0) | Major VII (2)<br>Major VIII (2)<br>Major P IV (2) | Minor VII (2)<br>Minor VIII (2)<br>Minor P IV (2) | OE-4(2) (T/P) | SEC-II (2) (T/P) | AEC-II (2)<br>(English)<br>VEC-II (2)<br>(Environmental studies) | CEP-I (2) | 22 | |
| Credits | 8(T)+4(P)=12 | 8(T)+4(P)=12 | 2+2=4(T/P) | 4(T/P) +2(P)=6 | 2+4=6 | 2+2=4 | 44 | Exit Option:4 credits NSQF/Internship/ Skill courses |

T : Theory

P: Practical

OE: Generic/Open Elective

VSC: Vocational Skill course

SEC: Skill Enhancement Courses

AEC: Ability Enhancement Course (English)

DSC: Discipline Specific Course

DSE: Discipline Specific Elective Course

VEC: Value Education Courses (Environmental Science)

IKS: Indian Knowledge System

OJT: On Job Training

FP: Field Projects

CEP: Community Engagement Practice

CC: Co-Curricular Courses

RP: Research Project

IDC: Interdisciplinary Course

## 12. Standard of Passing and Determination of SGPA/CGPA, Grading and Declaration of Results:

The Standard of passing shall be 35%. For B. Sc. (all Semesters) the student shall have to score as per this standard of passing shown in the following table:

| Maximum Marks | 100 | 80 | 50 | 40 | 20 | 10 |
|---|---|---|---|---|---|---|
| Minimum Marks required for passing | 35 | 28 | 18 | 14 | 7 | 4 |

There shall be a separate head of passing in Theory and Internal Examination. However, ATKT rules shall be made applicable in respect of Theory courses (University examination) only. For Environmental Studies (Semester IV, Examination) the student shall have to score mar ks 13 marks out of 35 in theory course and 5 marks out of 15 for project work.

**Gradation Chart:**

| Marks Obtained | Numerical Grade (Grade Point) | | CGPA | Letter Grade |
|---|---|---|---|---|
| Absent | 0 (zero) | | - | - |
| 0 – 34 | 0 to 4 | | 0.0 – 4.99 | F (Fail) |
| 35 – 44 | 5 | | 5.00 – 5.49 | C |
| 45 – 54 | 6 | | 5.50 – 6.49 | B |
| 55 – 64 | 7 | | 6.50 – 7.49 | B+ |
| 65 – 74 | 8 | | 7.50 – 8.49 | A |
| 75 – 84 | 9 | | 8.50 – 9.49 | A+ |
| 85 – 100 | 10 | | 9.50 – 10.0 | O (Outstanding) |

**Note:**

1. Marks obtained >= 0.5 shall be rounded off to next higher digit.
2. The SGPA & CGPA shall be rounded off to 2 decimal points.

**Calculation of SGPA& CGPA:**

**1.Semester Grade Point Average (SGPA)**

$$SGPA = \frac{\sum(Course\ credits\ \times Grade\ point\ obtained)\ of\ a\ semester}{\sum(Course\ credits)\ of\ a\ respective\ semester}$$

**2.Cumulative Grade Point Average (CGPA)**

$$CGPA = \frac{\sum(Total\ credits\ of\ a\ semester\ \times SGPA\ of\ respective\ semester)\ of\ all\ semester}{\sum(Total\ course\ credits)\ of\ all\ semesters}$$

**13. Nature of Question Paper, Duration and Scheme of Marking:**

**A) Theory Examinations**

a) Maximum Marks : 40

b) Duration : 1 hr 30 min

c) Nature of the Theory Examination Question Paper and Scheme of Marking

| Question No. | Nature/Type of Question | Marks |
|---|---|---|
| 1 | Multiple Choice Questions (MCQs)<br>(8 Questions) | 8 Marks<br>(1 Mark for Each Question) |
| 2 | Broad Answer/Descriptive Type Questions<br>(Attempt Any 2 Out of 3) | 16 Marks<br>(8 Marks for Each Question) |
| 3 | Short Note Type Questions<br>(Attempt Any 4 Out of 6) | 16 Marks<br>(4 Marks for Each Question) |
| | **Total Marks** | **40** |

**B) Practical Examinations**

a) The practical examination will be conducted on two consecutive days for six hours per day per batch.

b) Each candidate must produce a certificate from the Head of the Department in his/ her college, stating that he/she has completed in a satisfactory manner the practical course on lines laid down from time to time by Academic Council on the recommendations of Board of Studies and that the journal has been properly maintained. Every candidate must have recorded his/her observations in the laboratory journal and have written a report on each exercise performed. Every journal is to be checked and signed periodically by a member of teaching staff and certified by the Head of the Department at the end of the semester. Candidates must produce their journals at the time of practical examinations.

c) Candidates have to visit at least one place of microbiological interest (pharmaceutical / industry/dairy/research institute etc.) and submit the report of their visit.

**Nature of the Practical Examination Question Paper and Distribution of Marks**

- **Semester III**

| Question No. | Nature/Type of Question | Marks |
|---|---|---|
| 1 | SPC of given food sample | 10 |
| 2 | Isolation of bacteria from spoiled food | 10 |
| 3 | Detection of presence of *E. coli / Staphylococcus / Pseudomonas* from given food sample | 10 |
| 4 | Spotting | 10 |
| 5 | Journal | 10 |
| | **Total Marks** | **50** |

- **Semester IV**

| Question No. | Nature/Type of Question | Marks |
|---|---|---|
| 1 | Isolation of *Azotobacter* / *Rhizobium* / PSB from soil | 10 |
| 2 | Bioassay of Streptomycin / Tetracycline | 10 |
| 3 | Assay of Amylase / Protease | 10 |
| 4 | Tour report | 10 |
| 5 | Journal | 10 |
| | **Total Marks** | **50** |

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**with Multiple Entry and Multiple Exit**

**Syllabus For**

**B.Sc. Part II**

## INDUSTRIAL MICROBIOLOGY

**(MAJOR COURSE)**

**(Faculty of Science and Technology)**

**SEMESTER III AND IV**

**(To Be Implemented from Academic Year 2025-26)**

# B.Sc. Part II (NEP 2.0) Semester- III

## COURSE- V: INDUSTRIAL FERMENTED FOODS PRODUCTION, SPOILAGE, AND ITS PRESERVATION

**(MAJOR COURSE)**

**[CREDITS - 02; LECTURES - 30 Hours; LEC/WEEK – 02]**

**Learning Objectives**

1. To understand the industrial production processes of fermented dairy products, alcoholic beverages, and pickles
2. To learn the types and causes of spoilage in fermented dairy products, alcoholic beverages, and pickles
3. To identify spoilage organisms and their effects on product quality and safety
4. To explore preservation methods used for dairy products, alcoholic beverages, and pickles

| Unit I / Credit I | INDUSTRIAL PRODUCTION OF FERMENTED FOODS | No. of hours: 15 |
|---|---|---|

**A) Dairy Product**

1. Cheese 2. Yoghurt 3. Curd 4. Butter

**B) Alcoholic Beverages**

1. Wine: - Industrial production of -

   a) Red Table Wine b) Sparkling Wine-Champagne

2. Beer: - Industrial production of -

   a) Ale b) Lager

**C) Pickles**

1. Sauerkraut 2. Cucumber 3. Olive

| Unit II / Credit II | SPOILAGE OF FERMENTED FOODS AND ITS PRESERVATION | No. of hours: 15 |
|---|---|---|

**A) Spoilage of Dairy Product:**

1. Cheese 2. Yoghurt 3. Curd 4. Butter

**B) Spoilage of Alcoholic Beverages:**

1. Wine 2. Beer

**C) Spoilage of Pickles:**

1. Sauerkraut 2. Cucumber 3. Olive

**D) Preservation of :**

1. Dairy Product 2. Alcoholic Beverages 3. Pickles

## COURSE VI: QUALITY CONTROL AND ASSURANCE OF FOOD PRODUCTS

**(MAJOR COURSE)**

**[CREDITS - 02; LECTURES - 30 hours; LEC/WEEK – 02]**

**Learning Objectives**

1. To learn microbiological tests to check food quality and detect pathogens
2. To understand food quality regulations like PFA, FDA, FPO, ISO, BIS, and AGMARK
3. To learn the basics of GMP, GLP, and HACCP for food safety
4. To apply TQM and ICMSF guidelines in milk and food quality control

| Unit I / Credit I | QUALITY CONTROL OF FOOD PRODUCTS | No. of hours: 15 |
|---|---|---|

**A) Need of Microbiological quality control of food**

**B) Microbiological analysis of food products**

1. SPC
2. Detection for the presence of
   - I) Pathogenic bacteria
     - a. *E. coli*
     - b. *Staph. aureus*
     - c. *Shigella*
     - d. *Pseudomonas*
     - e. *Salmonella*
   - II) Yeast and mold

| Unit II / Credit II | INTRODUCTION TO QUALITY ASSURANCE OF FOOD PRODUCTS | No. of hours: 15 |
|---|---|---|

**A) Basic concepts of:** -

1. Regulation as per PFA, FDA & FPO.
2. Standards & Norms as per ISO, BIS, AGMARK

**B) Introduction of GMP & GLP**

**C) Introduction to HACCP** (Hazard Analysis Critical Control Points)

**D) TQMS** (Total Quality Management System) of milk and milk products-

1. Raw material acceptance
2. Process control
3. Packaging
4. Finished product storage
5. Transport and Distribution

**E) ICMSF (International Commission on the Microbiological Specification of Foods)**

1. Introduction
2. ICMSF–Sampling plans
   - a. The two class plan
   - b. The three class

## PRACTICAL COURSE III
**(MAJOR COURSE)**
**[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04]**

**Learning Objectives**

1. To produce sauerkraut and perform standard plate count (SPC) for fermented and dairy products
2. To isolate and identify spoilage bacteria from milk, cheese, and wine
3. To isolate and identify lactic acid bacteria from curd
4. To detect common foodborne pathogens and spoilage microbes from various food samples

| | | |
|---|---|---|
| **Unit I / Credit I** | 1) Production of sauerkraut<br>2) SPC of sauerkraut<br>3) SPC of buttermilk & cheese<br>4) Isolation of bacteria from spoiled milk<br>5) Isolation of bacteria from spoiled cheese<br>6) Isolation of bacteria from spoiled wine<br>7) Isolation and identification of Lactic acid bacteria from Curd | **No. of hours :30** |
| **Unit II / Credit II** | 1) Rapid detection of food pathogens – *E. coli* and *Staphylococcus* from given food sample<br>2) Detection for the presence of *E. coli* & *Staph. aureus* in butter<br>3) Detection for the presence of *Pseudomonas* from given food sample<br>4) Detection for the presence of *Salmonella* from given food sample<br>5) Detection for the presence of Yeast and molds from given food sample | **No. of hours :30** |

# B.Sc. Part II (NEP 2.0) Semester-IV

## COURSE VII: FERMENTATION TECHNOLOGY
**(MAJOR COURSE)**
**[CREDITS - 02; LECTURES - 30 hours; LEC/WEEK – 02]**

**Learning Objectives:**

1. To understand the industrial production process of antibiotics and organic acids
2. To identify raw materials and microbes used in fermentation for pharmaceutical products
3. To learn the steps of recovery and applications of amino acids and enzymes
4. To explore the role of fermentation in producing valuable bio-products like antibiotics, acids, and enzymes

| Unit I / Credit I | Fermentation of Pharmaceutical products | No. of hours: 15 |
|---|---|---|

**Industrial production:** -

Raw materials, Microorganisms, production process, Recovery and Applications:

**A) Antibiotics**

1. Streptomycin
2. Tetracycline
3. Rifampicin

**B) Organic Acids**

1. Lactic Acid
2. Citric Acid

| Unit II / Credit II | Fermentation of Amino acids & Enzymes | No. of hours: 15 |
|---|---|---|

**Industrial production:** -

Raw materials, Microorganisms, production process, Recovery and Applications:

**A) Amino acids**

1. Lysine
2. Glutamic Acid

**B) Enzymes**

1. Amylases
2. Lipase
3. Proteases

## COURSE VIII: INDUSTRIAL PRODUCTION OF BIOFERTILIZERS

**(MAJOR COURSE)**

**[CREDITS - 02; LECTURES - 30 hours; LEC/WEEK – 02]**

**Learning Objectives:**

1. To understand the role and need of nitrogen-fixing biofertilizers in organic farming
2. To learn the characteristics, production, and application of Rhizobium, Azotobacter, and Azospirillum biofertilizers
3. To study the types, functions, and application methods of VAM and PSB biofertilizers
4. To understand FCO guidelines for quality control, sampling, and standards of biofertilizers

| Unit I / Credit I | Nitrogen fixing Bio-fertilizers | No. of hours: 15 |
|---|---|---|

**A) Concept & its need in organic farming**

**a) *Rhizobium* Biofertilizer**

1. Characteristics
2. Host-Rhizobium interaction
3. $N_2$-fixation in root-nodules
4. Production
5. Methods of application:

**b) *Azotobacter* Biofertilizer**

1. Characteristics
2. $N_2$-fixation process
3. Production
4. Methods of application

**c) *Azospirillum* Biofertilizer**

1. Characteristics
2. Association with plants
3. Production
4. Methods of application

| Unit II / Credit II | Phosphate Solubilizing Bio-fertilizers | No. of hours: 15 |
|---|---|---|

**A) VAM Biofertilizer**

1. Characteristics & types of association
2. Production
3. Methods of application

**B) PSB Biofertilizer (Phosphate Solubilizing Bacteria)**

1. Mechanism of phosphate solubilization
2. Production
3. Methods of application

**C) Quality control of Biofertilizers as per FCO (Fertilizer Control Order)**

1. Introduction of FCO specifications for biofertilizers
2. Sampling procedure
3. Method of analysis
4. Standards of biofertilizers
5. Biostability of product biofertilizer

| PRACTICAL COURSE IV<br>(MAJOR COURSE)<br>[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04] | | |
|---|---|---|
| **Learning Objectives:**<br>1. To isolate and identify industrial and agricultural microorganisms<br>2. To produce and purify citric acid, enzymes, and antibiotics using fermentation methods<br>3. To estimate fermentation products using standard assay techniques<br>4. To apply enzyme immobilization and perform microbial limit tests for quality control | | |
| **Unit I / Credit I** | 1) Isolation of lipolytic & proteolytic producing microorganisms from suitable source<br>2) Production, extraction, purification of Citric acid<br>3) Production of amylase by a Surface culture method<br>4) Production of protease by Submerged culture method<br>5) Estimation of following fermentation products by suitable assay method<br>a) Antibiotics–Streptomycin &Tetracycline (Diffusion assay method)<br>b) Organic Acids–Lactic acid & Citric acid by titration method<br>c) Enzymes–Amylase (DNSA method)<br>6) Immobilization of Amylase by using Sodium Alginate method<br>7) Assay of protease (Folin Ciocalteu method) | **No. of hours: 30** |
| **Unit II/ Credit II** | 1) Isolation of *Azotobacter* from soil<br>2) Isolation of *Azospirillum* from soil<br>3) Isolation of *Rhizobium* from root-nodules<br>4) Isolation of Phosphate solubilizing bacteria from soil<br>5) Determination of heterocyst frequency of blue-green bacteria<br>6) Microbial limit test for PSB market fertilizer product | **No. of hours: 30** |

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**Syllabus For**

**B.Sc. Part II**

## INDUSTRIAL MICROBIOLOGY

**(MINOR COURSE)**

**(Faculty of Science and Technology)**

**SEMESTER III AND IV**

**(To Be Implemented from Academic Year 2025-26)**

# B.Sc. Part II (NEP 2.0) Semester- III

## COURSE- V:INDUSTRIAL MICROORGANISM AND FERMENTOR
**(MINOR COURSE)**
**[CREDITS - 02; LECTURES - 30 Hours; LEC/WEEK – 02]**

**Learning Objectives**

1. To learn basic parts of Fermentor
2. To understand types of fermentation
3. To learn the basics of types of fermentation process

| Unit I / Credit I | INDUSTRIAL IMPORTANT MICROORGANISM & SELECTION METHODS | No. of hours: 15 |
|---|---|---|

A) Introduction of Industrial Microbiology.
B) Importance of Industrial Microorganism-Yeast, Mold, Bacteria & Actinomycetes.
C) Selection of industrially useful microbes.
D) Step to maintain seed culture & inoculation strategies for enhanced product yield.

| Unit II / Credit II | FERMENTOR, FERMENTATION & STERILIZATION | No. of hours: 15 |
|---|---|---|

A) Basic concept of Fermentor- Design of Fermentor- Agitation, aeration, antifoam, pH and temperature control, Physico-chemical standard used in fermentors.

B) Types of fermentation - Batch, Fed batch, Continuous, Multi stage continuous.

C) Fermentation process- Submerged, Surface, Solid state & Dual or multiple fermentation.

D) Sterilization of medium: The design of batch and continuous sterilization process.

E) Sterilization of air (Mechanism of filtration, introduction to absolute and depth filters)

## COURSE VI: SCREENING & FERMENTATION MEDIA
**(MINOR COURSE)**
**[CREDITS - 02; LECTURES - 30 hours; LEC/WEEK – 02]**

**Learning Objectives**

1. To learn the basic understanding of screening
2. To learn the screening methods
3. To understand the fermentation media and component
4. To learn the production of microbial metabolite

| Unit I / Credit I | MEDIUM &TYPES OF SCREENING | No. of hours: 15 |
|---|---|---|
| A) Introduction of Inoculation Media & Fermentation media<br>B) Raw materials used in fermentation industry & their processing.<br>C) Screening -Primary Screening & Secondary Screening<br>D) Probiotic: a.Basic Concept<br>b.Application of probiotic | | |
| **Unit II / Credit II** | **FERMENTATION MEDIA** | **No. of hours: 15** |
| A) Recovery of fermentation product- Methods for<br>cell lysis,<br>Physical separation,<br>Liquid- liquid Extraction,<br>Precipitation,<br>Chromatography & Drying.<br><br>B) Fermentation Media - Water,<br>Carbon source,<br>Nitrogen source,<br>Precursors,<br>Growth factors ,<br>Antifoam agents &<br>Chelating agents<br>C)Factors Affecting during fermentation<br>Production Microorganism,<br>Inoculum preparation,<br>Production medium,<br>Fermentation material,<br>Aeration &Agitation,<br>Temperature,<br>pH, Foamimg &<br>Contamination | | |

## PRACTICAL COURSE III
**(MINOR COURSE)**
**[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04]**

**Learning Objectives**

1. To learn about sterilization methods
2. To study preparation of inoculum, production and seed culture.
3. To isolate and identify lactic acid bacteria from curd
4. To learn effect of environmental factor on growth of Microorganism.
5. To detect antibiotic producing microorganism.
6. To study extraction of fermentation products.

| | | |
|---|---|---|
| **Unit I / Credit I** | 1) Sterilization of Glassware,Media and Air<br>2) Preparation of Inoculation media<br>3) Preparation of Production medium<br>4) Preparation of Inoculum/ Seed culture.<br>5) Determination of TDT and TDP<br>6) Effect of pH on bacterial growth<br>7) Effect of salt concentrations on bacterial growth<br>8) Shake flask fermentation method (Study of effect of agitation) | **No. of hours: 30** |
| **Unit II / Credit II** | 1) Isolation and identification of Lactic acid bacteria from Curd.<br>2) Primary screening of - Antibiotic by crowded plate technique.<br>3) Primary screening of producing Amino acid<br>4) Secondary screening of - Antibiotic by giant colony technique.<br>5) Fermentation Product separation by Filtration method<br>6) Fermentation Product separation by Precipitation method. | **No. of hours: 30** |

# B.Sc. Part II (NEP 2.0) Semester-IV

## COURSE VII: IMPROVEMENT, PRESERVATION & MICROBIAL PRODUCTION OF METABOLITES
## (MINOR COURSE)
## [CREDITS - 02; LECTURES - 30 hours; LEC/WEEK – 02]

**Learning Objectives:**

1. To learn the steps of Improvement and preservation of Microorganism
2. To understand the industrial production process of antibiotics and organic acids
3. To identify raw materials and microbes used in fermentation for pharmaceutical products
4. To explore the role of fermentation in producing valuable bio-products like antibiotics, acids, and enzymes.

| Unit I / Credit I | IMPROVEMENT AND PRESERVATIONOF INDUSTRIALLY IMPORTANT | No. of hours: 15 |
|---|---|---|

**A) Improvement of industrially important microorganisms:**

a.Selection of natural variants,
b.Selection of induced mutants,
c.Use of recombinant systems and genetic engineering.

B) **Preservation of industrially important microorganism.**

a. Cryopreservation
b. Lyophilization (Freeze-Drying)
c. **Storage under mineral oil**

| Unit II / Credit II | FERMENTATION OF MICROBIAL METABOLITES | No. of hours: 15 |
|---|---|---|

**Microbial production of Metabolites**

A) Microbial Production of Vitamins: a. Vitamin B12 - Organism used, production method process, recovery and assay.

B) Microbial Production of Protease b.Protease-Organism used, production method process, recovery and assay.

C) Microbial Production of organic acid a. Gluconic acid
b. Indole Acetic Acid

## COURSE VIII: INDUSTRIAL PRODUCTION & BIOASSAY

**(MINOR COURSE)**

**[CREDITS - 02; LECTURES - 30 hours; LEC/WEEK – 02]**

**Learning Objectives:**

1. To understand the role and need of antimicrobial agents
2. To study the types, functions, and application methods of antimicrobial agents.
3. To study check quality of antimicrobial agents.
4. To understand the role microorganism in fuel.

| Unit I / Credit I | MICROBIAL PRODUCTION OF ANTIBIOTIC AND BIOINSECTICIDES | No. of hours: 15 |
|---|---|---|

A) Production of Antibiotics: a.Chloramphenicol

B) Production of Biopesticides: a. *Bacillus thuringiensis*

b. *Trichoderma*

C) Production of Bioinsecticide: a.*Beauveria bassiana*

| Unit II / Credit II | BIOASSAY AND MICROBIAL FUEL | No. of hours: 15 |
|---|---|---|

A) Microbiological Assay- Diffusion assay
Turbidimetric assay
End-point determination assay
Enzymatic assay

B) Microbial Fuel Cells: Types and Applications

## PRACTICAL COURSE IV
**(MINOR COURSE)**
**[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04]**

**Learning Objectives:**

1. To isolate and identify industrial and agricultural microorganisms
2. To produce enzymes, organic acid and antibiotics using fermentation methods
3. To produce biopesticede using suitable method
4. To estimate fermentation products using standard assay techniques

| | | |
|---|---|---|
| **Unit I / Credit I** | 1) Isolation of proteolytic producing microorganisms from suitable source.<br>2) Isolation of organic acid producing microorganisms from suitable source.<br>3) Bioassay of Vit B12 by using agar diffusion method.<br>4) Isolation of *Bacillus thuringiensis* from suitable source.<br>5) Isolation of *Trichoderma* from suitable source. | **No. of hours: 30** |
| **Unit II/ Credit II** | 1) Production of protease by Submerged culture method<br>2) Production of Gluconic acid by Submerged culture method<br>3) Production of IAA by Submerged culture method<br>4) Estimation of following fermentation products by suitable assay method<br>a) Antibiotics–Chloramphenicol (Diffusion assay method)<br>b) Organic Acids– Gluconic acid & IAA by titration method<br>5) Preservation of culture in slants, glycerol stock and wax. | **No. of hours: 30** |

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**Syllabus For**

**B.Sc. Part II**

## SKILL ENHACEMENT COURSE
## IN INDUSTRIAL MICROBIOLOGY

**(Faculty of Science and Technology)**

**SEMESTER III AND IV**

**(To Be Implemented from Academic Year 2025-26)**

# B.Sc. Part II (NEP 2.0) Semester-III

## SKILL ENHANCEMENT COURSE-1 (SEC- 1): FUNDAMENTAL PRACTICES IN MICROBIOLOGY LABORATORY-I

**[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04]**

**Learning Objectives**

1. To learn basic microbiological skills
2. To demonstrate the preparation of common laboratory solutions, stains, and buffers, and understand their applications in microbiological experiments
3. To master laboratory techniques for calibration of glass materials and equipment
4. To understand and apply sterilization techniques for media, glassware, and heat-sensitive materials using autoclaving, hot air ovens, and UV light, and evaluate the sterility of these items

| Practical No. | Title of Experiment |
|---|---|
| 1 | Preparation of solutions- 1N HCl, 1N NaOH, 0.85% saline |
| 2 | Preparation of stains- 0.5% crystal violet and 0.5% basic fuchsin |
| 3 | Preparation of buffers- phosphate buffer pH-7 |
| 4 | Calibration of pipette, burette and measuring cylinder |
| 5 | Calibration of pH meter |
| 6 | Separation of amino acids from mixtures by paper chromatography |
| 7 | Learning basic techniques in microbiology: Wrapping of glassware, making cotton plugs and plugging different glassware, |
| 8 | Sterilization of medium using autoclave and assessment for sterility |
| 9 | Sterilization of glassware using hot air oven and assessment for sterility |
| 10 | Sterilization of heat sensitive material by UV light and assessment for sterility |

# B.Sc. Part II (NEP 2.0) Semester-IV

## SKILL ENHANCEMENT COURSE- 2 (SEC-2):
## FUNDAMENTAL PRACTICES IN MICROBIOLOGY LABORATORY-II
**[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04]**

**Learning Objectives**

1. To learn techniques for preparing and preserving microbial cultures
2. To gain proficiency in microscopic examination and identification of microorganisms
3. To apply microbiological methods to assess the safety and quality of food and water
4. To understand and apply methods for detecting microorganisms in food and pharmaceutical products

| Practical No. | Title of Experiment |
|---|---|
| 1 | Preparation of agar slants and agar butts |
| 2 | Preservation of microbial cultures by subculturing |
| 3 | Microscopic examination of algae |
| 4 | Mounting of fungi by using lactophenol cotton blue |
| 5 | Determination of potability of water by MPN test |
| 6 | SPC of food products- tomato sauce |
| 7 | SPC of packaged drinking water |
| 8 | Check sterility of pharmaceutical products – fluids & powders |
| 9 | Detection of yeast from given food samples |
| 10 | Detection of coliform from street foods- Pani puri and Vada pav |

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**B.Sc. Part II**

## VOCATIONAL SKILL COURSE
## IN INDUSTRIAL MICROBIOLOGY

**(Faculty of Science and Technology)**

**SEMESTER III**

**(To Be Implemented from Academic Year 2025-26)**

# B.Sc. Part II (NEP 2.0) Semester-III

## VOCATIONAL SKILL COURSE-1 (VSC- 1): MILK TESTING AND QUALITY CONTROL

**[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04]**

**Learning Objectives**

1. To operate essential laboratory equipment used in milk testing and quality control
2. To perform accurate milk sampling, preservation, and physical analysis techniques
3. To apply the phosphatase test and other methods to ensure milk safety and pasteurization efficiency
4. To gain practical insights into industrial milk processing and quality assurance

| Practical No. | Title of Experiment |
|---|---|
| 1 | Demonstration of laboratory equipment<br>Incubator, Hot air oven, Water bath, Laminar air flow, Gerber's centrifuge |
| 2 | Milk sampling techniques and preservation of milk samples for different tests |
| 3 | Physical analysis of milk<br>Organoleptic tests- Flavour, Colour, Taste |
| 4 | Chemical analysis of milk<br>a) Measurement of pH of Milk and Milk Products<br>b) Clot on Boiling<br>c) Alcohol Test for Milk<br>d) Inhibitor Test<br>e) Acidity Test<br>f) Detection of Adulterant- Soap, Common salt, SMP, Starch, Formalin, etc |
| 5 | Microbiological analysis of milk<br>a) Dye Reduction Test – MBRT<br>b) SPC for Milk<br>c) Direct Microscopic Count<br>d) Yeast or mold count<br>e) Test for Coliforms |
| 6 | Phosphatase test |

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**B.A. Part II /B. Com. Part II**

## OPEN ELECTIVE COURSE
## IN INDUSTRIAL MICROBIOLOGY

**SEMESTER III AND IV**

**(To Be Implemented from Academic Year 2025-26)**

# B. A. Part II / B. Com. Part II (NEP 2.0) Semester-III

## OPEN ELECTIVE COURSE-3 (OE-3):
## MICROORGANISMS IN EVERYDAY LIFE
**[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04]**

**Learning Objectives**

1. To identify and observe the presence of microflora in various environments
2. To understand the role of microorganisms in human health and their implications for hygiene practices
3. To analyze the factors influencing microbial presence and growth in different environments and discuss their health and ecological implications
4. To evaluate the effectiveness of hygiene methods in reducing microbial growth

| Practical No. | Title of Experiment |
|---|---|
| 1 | Observation of the presence of microflora in air |
| 2 | Observation of the presence of microflora in water |
| 3 | Observation of the presence of microflora on the skin |
| 4 | Observation of the presence of microflora from nails |
| 5 | Observation of the presence of microflora from teeth |
| 6 | Proper hand washing technique |
| 7 | Effect of soap and disinfectant on growth of microorganisms |
| 8 | Effect of sanitizer on growth of microorganisms |
| 9 | Observation of the presence of microflora from soil |
| 10 | Observation of the presence of microflora on currency-coin |

## OPEN ELECTIVE COURSE-3 (OE-3):
## रोजच्या जीवनातील सूक्ष्मजीव

**[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04]**

**शिकण्याची उद्दिष्टे**

1. विविध वातावरणातील सूक्ष्मजीवसृष्टीची ओळख व निरीक्षण करणे.
2. मानवी आरोग्यात सूक्ष्मजीवांची भूमिका समजून घेणे आणि स्वच्छता पद्धतींवरील त्यांचे परिणाम समजावून घेणे.
3. वेगवेगळ्या वातावरणातील सूक्ष्मजीवांची उपस्थिती आणि वाढ यावर परिणाम करणारे घटक विश्लेषित करणे आणि त्यांच्या आरोग्य व पर्यावरणीय परिणामांवर चर्चा करणे.
4. सूक्ष्मजीवांच्या वाढीला आळा घालण्यासाठी स्वच्छता पद्धतींच्या प्रभावीतेचे मूल्यांकन करणे.

| अ. क्र. | प्रयोगाचे नाव |
|---|---|
| 1 | हवेतील सूक्ष्मजीवांच्या उपस्थितीचे निरीक्षण करणे |
| 2 | पाण्यातील सूक्ष्मजीवांच्या उपस्थितीचे निरीक्षण करणे |
| 3 | त्वचेवरील सूक्ष्मजीवांच्या उपस्थितीचे निरीक्षण करणे |
| 4 | नखांवरील सूक्ष्मजीवांच्या उपस्थितीचे निरीक्षण करणे |
| 5 | दातांवरील सूक्ष्मजीवांच्या उपस्थितीचे निरीक्षण करणे |
| 6 | हात धुण्याची योग्य पद्धत अभ्यासणे |
| 7 | साबण आणि जंतुनाशकाचा सूक्ष्मजीवांच्या वाढीवरील प्रभाव अभ्यासणे |
| 8 | सॅनिटायझरचा सूक्ष्मजीवांच्या वाढीवरील प्रभाव अभ्यासणे |
| 9 | मातीतील सूक्ष्मजीवांच्या उपस्थितीचे निरीक्षण करणे |
| 10 | चलन- नाण्यावरील सूक्ष्मजीवांच्या उपस्थितीचे निरीक्षण करणे |

# B. A. Part II / B. Com. Part II (NEP 2.0) Semester-IV

## OPEN ELECTIVE COURSE- 4 (OE-4):
## THE ROLE OF MICROORGANISMS
**[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04]**

**Learning Objectives**

1. To cultivate microorganisms on natural surfaces
2. To examine and observe microbial spoilage in various food and plant products
3. To learn the significance of root nodules in leguminous plants
4. To understand the preparation of beneficial microbial inoculants for plant applications
5. To study commonly used biofertilizers, biopesticides and bioinsecticides

| Practical No. | Title of Experiment |
|---|---|
| 1 | Cultivation of microorganisms on natural surfaces- Coconut and Orange fruit |
| 2 | Collection and observation of spoiled food products- Bread and Milk |
| 3 | Collection and observation of spoiled fruits- Banana and Apple |
| 4 | Observation of common symptoms of plant diseases caused by microorganisms-Citrus canker, Black rust of wheat, and Whip-smut of sugar cane |
| 5 | Microbial spoilage of paper and leather products |
| 6 | Collection and importance of root nodules of leguminous plants |
| 7 | Preparation of beneficial microbial inoculants for plant applications |
| 8 | Study of commonly used biofertilizers |
| 9 | Study of commonly used biopesticides |
| 10 | Study of commonly used bioinsecticides |

## OPEN ELECTIVE COURSE- 4 (OE-4):

## सूक्ष्मजीवांची भूमिका

**[CREDITS -02, TOTAL HOURS- 60, PRACTICALS /WEEK - 04]**

**शिकण्याची उद्दिष्टे**

1. नैसर्गिक पृष्ठभागांवर सूक्ष्मजीवांची वाढ करणे.
2. विविध अन्न आणि वनस्पती उत्पादनांमध्ये सूक्ष्मजीवांमुळे होणाऱ्या खराबीचे निरीक्षण व परीक्षण करणे.
3. डाळवर्गीय वनस्पतींमध्ये मुळावरील गाठींचे महत्त्व समजून घेणे.
4. वनस्पतींसाठी उपयुक्त सूक्ष्मजीव संवर्धनाची तयारी समजून घेणे.
5. प्रचलित जैविक खते आणि जैविक कीटकनाशकांचे अध्ययन करणे.

| अ. क्र. | प्रयोगाचे नाव |
|---|---|
| 1 | नैसर्गिक पृष्ठभागांवर सूक्ष्मजीवांची वाढ करणे - नारळ आणि संत्री फळ |
| 2 | खराब झालेल्या अन्नपदार्थांचे संकलन आणि निरीक्षण करणे - ब्रेड आणि दूध |
| 3 | खराब झालेल्या फळांचे संकलन आणि निरीक्षण करणे - केळे आणि सफरचंद |
| 4 | सूक्ष्मजीवांमुळे वनस्पतींना होणाऱ्या आजारांची सामान्य लक्षणे अभ्यासणे - सिट्रस कॅंकर, गव्हावरील काळी गंज, आणि ऊसावरील व्हीप-स्मट |
| 5 | कागद आणि चामड्याच्या उत्पादनांवर सूक्ष्मजीवांमुळे होणारे नुकसान अभ्यासणे |
| 6 | डाळींबंधातील वनस्पतींच्या मुळावरील गाठींचे संकलन करणे आणि त्यांचे महत्त्व अभ्यासणे |
| 7 | वनस्पतींसाठी उपयुक्त सूक्ष्मजीवसंवर्धनाची तयारी करणे |
| 8 | प्रचलित जैविक खतांचे अध्ययन करणे |
| 9 | प्रचलित जैविक कीटकनाशक - बायोपेस्टीसाइड्स यांचे अध्ययन करणे |
| 10 | प्रचलित जैविक कीटकनाशक - बायोइन्सेक्टिसाइड्स यांचे अध्ययन करणे |

**LIST OF REFERENCE BOOKS FOR THEORY & PRACTICAL**


1. Food Microbiology by Frazier.
2. Food Microbiology by H. A. Modi. (Vol. I&II)
3. Industrial Microbiology by A. H. Patel.
4. Industrial Microbiology by Prescott & Dunn.
5. Soil Microbiology by Subbarao.
6. Agriculture Microbiology by Rangaswamy.
7. Methods in Food and Dairy Microbiolgy by Harrigon.
8. Bio fertilizers –Vyas & Vyas (Ekta Publication).
9. Bacteriological Techniques- F.K. Baker
10. Milk & milk products–Winton & Winton
11. Pharmaceutical Microbiology–Hugo & Russell.
12. Citric acid Biotechnology–J. Achrekar.
13. Enzyme Biotechnology–G. Tripathi.
14. Bio fertilizers– Arun Sharma.
15. Industrial Microbiology–Agrawal / Parihar
16. Biotechnology–S. S. Purohit.
17. Agriculture Microbiology–G. Rangaswami & D. J. Bagyaraj
18. Text-book of Biotechnology–G. R. Chhatwal.
19. Pharmaceutical Biotechnology–Purohit / Kakrani / Saluja.
20. Practical Microbiology–R. C. Dubey and D. K. Maheshwari
21. Experimental Microbiology–Rakesh J. Patel & Kiran R. Patel. (Vol.I&II)
22. Fertilizer Control Order–1985 amended up to June, 2011
23. Practical Biochemistry by Plummer.


**List of the minimum equipments for B.Sc. Part II Industrial Microbiology course**

All the equipments required for B.Sc. Part I Industrial Microbiology course

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**Syllabus For**

## UG DIPLOMA EXIT OPTION

**(4 Credit Course)**

## INDUSTRIAL MICROBIOLOGY

**(Faculty of Science and Technology)**

**(To Be Implemented from Academic Year 2025-26)**

## COURSE I: FERMENTATION TECHNOLOGY

**[CREDITS - 02; LECTURES - 30 hours; LEC/WEEK – 02]**

**Learning Objectives:**

1. To understand the industrial production process of antibiotics and organic acids
2. To identify raw materials and microbes used in fermentation for pharmaceutical products
3. To learn the steps of recovery and applications of amino acids and enzymes
4. To explore the role of fermentation in producing valuable bio-products like antibiotics, acids, and enzymes

| Unit I / Credit I | Fermentation of Pharmaceutical products | No. of hours: 15 |
|---|---|---|

**Industrial production:** -

Raw materials, Microorganisms, production process, Recovery and Applications:

**A) Antibiotics**

1. Streptomycin
2. Tetracycline
3. Rifampicin

**B) Organic Acids**

1. Lactic Acid
2. Citric Acid

| Unit II / Credit II | Fermentation of Amino acids & Enzymes | No. of hours: 15 |
|---|---|---|

**Industrial production:** -

Raw materials, Microorganisms, production process, Recovery and Applications:

**A) Amino acids**

1. Lysine
2. Glutamic Acid

**B) Enzymes**

1. Amylases
2. Lipase
3. Proteases

## COURSE II: INDUSTRIAL PRODUCTION OF BIOFERTILIZERS

**[CREDITS - 02; LECTURES - 30 hours; LEC/WEEK – 02]**

**Learning Objectives:**

1. To understand the role and need of nitrogen-fixing biofertilizers in organic farming
2. To learn the characteristics, production, and application of Rhizobium, Azotobacter, and Azospirillum biofertilizers
3. To study the types, functions, and application methods of VAM and PSB biofertilizers
4. To understand FCO guidelines for quality control, sampling, and standards of biofertilizers

| Unit I / Credit I | Nitrogen fixing Bio-fertilizers | No. of hours: 15 |
|---|---|---|

**A) Concept & its need in organic farming**

**a) *Rhizobium* Biofertilizer**

1. Characteristics
2. Host-Rhizobium interaction
3. $N_2$-fixation in root-nodules
4. Production
5. Methods of application:

**b) *Azotobacter* Biofertilizer**

1. Characteristics
2. $N_2$-fixation process
3. Production
4. Methods of application

**c) *Azospirillum* Biofertilizer**

1. Characteristics
2. Association with plants
3. Production
4. Methods of application

| Unit II / Credit II | Phosphate Solubilizing Bio-fertilizers | No. of hours: 15 |
|---|---|---|

**A) VAM Bio-fertilizer**

1. Characteristics & types of association
2. Production
3. Methods of application

**B) PSB Biofertilizer (Phosphate Solubilizing Bacteria)**

1. Mechanism of phosphate solubilization
2. Production
3. Methods of application

**C) Quality control of Biofertilizers as per FCO (Fertilizer Control Order)**

1. Introduction of FCO specifications for biofertilizers
2. Sampling procedure
3. Method of analysis
4. Standards of biofertilizers
5. Biostability of product biofertilizer