University of Pune

Three Year B. Sc. Degree Course in

INDUSTRIAL MICROBIOLOGY (VOCATIONAL)

Syllabus

(To be implemented from Academic Year 2013-14)

Preamble:

The 3-year B.Sc. Vocational Course in Industrial Microbiology is conducted as a part of the University of Pune approved course in B.Sc. Microbiology. Industrial Microbiology is offered as one of the subjects among the four subjects at the F.Y.B.Sc. level and among the three subjects at S.Y.B.Sc. level. At the T.Y.B.Sc. level, there are two theory courses and one practical course to be offered along with four theory courses and two practical courses of T.Y.B.Sc. Microbiology.

The course "Industrial Microbiology" is being coordinated and conducted by the Department of Microbiology at the concerned centres.

It is therefore to be understood that this syllabus will only operate when it is offered to students who have the basic knowledge of Microbiology, and in certain cases, Biotechnology at the undergraduate level.

It is therefore necessary that the syllabus of B.Sc. Microbiology is simultaneously considered, and that the course in Industrial Microbiology is an add-on information and practice, along with concomitant studies in Microbiology.

In keeping with the purpose of introducing vocational courses in the affiliated colleges of the University of Pune, and as given in the previous statements of intent by the Board of Studies, the vocational courses are expected to be:

1. Specialized in the sense of being **non-conventional**.
2. They are expected to be **multi-faculty** as well as **multidisciplinary**.
3. The concerned Board of Studies is supposed to keep a **holistic view** and **integrated approach**.
4. The courses are **expected to be different** also because they are incorporated into conventional disciplines.
5. The courses are expected to **establish a linkage with main stream disciplines, market and industry**.

Introduction:

There is a continual demand for microbiologists in the work force – education, industry and research. Career opportunities for the graduate students are available in manufacturing industry and research institutes at technical level. This course focuses on training students on how microbiological techniques are carried out in industrial practices. Though the fundamentals of microbiological practices remains the same in theory and industrial practice, there are several facets of even simple microbiological practices that are exclusive to industry. For example, validation of procedures and processes are an integral part of industrial production. This is not taught in practicals at the B.Sc. level. Also, some practices in industry, though simple and sometimes monotonous, need to be standardized. Such standardization procedures are also not extensively taught at the B.Sc. level.

The proposed syllabus lays more stress on practicals as compared to theory. This course will concentrate on experimental practice, and theoretical aspects will be oriented to explain and discuss the experimental practices. This approach justifies the term 'vocational'.

The teaching centre at the college will develop trained manpower for industry, such that employability immediately after B.Sc. is possible.

Trained and competent teachers with experience in industry would be ideal to teach the subject. Besides such teachers, persons from industry could contribute to the course.

Objectives to be achieved:

- To promote the possibility of self employment after B.Sc.
- To bridge up the gap between knowledge based conventional education and market demands and to provide an alternative to those pursuing higher education.
- To enrich students' training and knowledge to practices of Microbiology in industry
- To introduce the concepts of experimental design in Microbiology
- To inculcate sense of job responsibilities, while maintaining social and environment awareness
- To help students build-up a progressive and successful career in industries with a biotechnological perspective

Eligibility

1. First Year B.Sc.:

a. Higher Secondary School Certificate (10+2) or its equivalent Examination with English and Biology; and two of the science subjects such as Physics, Chemistry, Mathematics, Geography, Geology, etc. OR

b. Three Years Diploma in Pharmacy Course of Board of Technical Education conducted by Government of Maharashtra or its equivalent. OR

c. Higher Secondary School Certificate (10+2) Examination with English and vocational subject of + 2 level (MCVC) - Medical Lab. Technician (Subject Code = P1/P2/P3). The students should have appeared for Biology as one of their subjects.

2. Second Year B.Sc.:

The students should pass in all subjects at the F.Y.B.Sc. level or at least keep terms (ATKT) of First Year of B. Sc. with Microbiology and Industrial Microbiology as two of the subjects at the F.Y.B.Sc. level. In addition to the above qualification, students who have passed the Diploma course in Pharmacy are eligible however such cases should be approved by equivalence committee of Faculty of Science of the University of Pune.

3. Third Year B. Sc.:

The student should compulsorily clear all First Year B. Sc. Microbiology and Industrial Microbiology courses and satisfactorily keep terms (at least ATKT) of Second Year of B. Sc. with Microbiology and Industrial Microbiology as two of their subjects. Students who may have passed in all subjects at the S.Y.B.Sc. level, but have not cleared all the courses at F.Y.B.Sc. level are not eligible to be admitted to the T.Y.B.Sc. class.

Admissions will be given as per the selection procedure / policies adopted by the respective college keeping in accordance with conditions laid down by the University of Pune.

Reservation and relaxation will be as per the State Government rules.

Standard of Passing

i. In order to pass in the First Year Theory Examination, the candidate has to obtain at least 40 marks out of 100 in each Theory Course. (Minimum 32 marks must be obtained in the University Theory Examination).
ii. In order to pass in the Second Year and Third Year Theory Examinations, the candidate has to obtain at least 20 marks out of 50 in each course of each semester. (Minimum 16 marks must be obtained in the University Theory Examination).
iii. In order to pass in Practical Examination, the candidate has to obtain at least 40 marks out of 100 in each course. (Minimum 32 marks must be obtained in the University Examination).

Award of Class

The class will be awarded to the student on the aggregate marks obtained during the Second and Third year in the Principle subject only. The award of the class shall be as follows:

1	Aggregate 70% and above	First Class with Distinction
2	Aggregate 60% and more but less than 70%	First Class
3	Aggregate 55% and more but less than 60%	Higher Second Class
4	Aggregate 50% and more but less than 55%	Second Class
5	Aggregate 40% and more but less than 50%	Pass Class
6	Below 40%	Fail

ATKT Rules

While progressing from F. Y. B. Sc. to S. Y. B. Sc. Class, the student has to pass in at least 8 courses (out of total 12).

While going from S. Y. B. Sc. to T. Y. B. Sc., at least 12 courses (out of 20) should be cleared (Practical Course at S. Y. B. Sc. will be equivalent to 2 courses). The student will not be able to progress from S.Y.B.Sc. to T.Y.B.Sc. unless all his / her F. Y. B. Sc. courses are cleared.

Equivalence of Previous Syllabus

	Previous Syllabus	Present Syllabus
Theory	Theory Course I (Both Sections)	Theory Course I
Theory	Theory Course II (Both Sections)	Theory Course II
Practical	Practical Course	Practical Course

External Students

There shall be no external students.

University Terms

Dates for commencement and conclusion for the First and Second Terms will be declared by the University authorities. Terms can be kept by only duly admitted students. The term shall be granted only on minimum 80 percent attendance at theory and practical course and satisfactory performance during the term.

Medium of Instruction: The medium of instruction for the course shall be English.

Course Structure:

Duration: The duration of B.Sc. (Industrial Microbiology) Degree Program shall be three years.

The syllabus has been structured to progressively inform and discuss the concepts and working areas of the fermentation / biotechnology industry. The training for skill sets required to perform the tasks in the industry has been concomitantly developed through the three-year course.

In the **First Year of undergraduate studies**, students will be given information about the spectrum of microorganisms used for production of useful metabolites and enzymes (catalysts). A typical layout of the industry, equipment and operations, and regulations governing the organisms and products are presented to the student. This information lays the foundation for detailed study of each facet in the progressive years. In the practical exercises, students will learn the basic techniques of microbiological procedures in the industrial context.

In the **Second Year of undergraduate studies**, methods of screening of microorganisms and media, details of operations and designs of bioreactors, processes for production of industrially important metabolites and procedures of quality assurance will be studied. The focus of these topics is to reveal to the students the different strategies used for designing and directing the metabolism of a production strain to overproduce the metabolite, and recover it. The practical exercises use examples to explain the procedures described in the theory courses.

In the **Third Year of undergraduate studies**, the students of Industrial Microbiology share four theory courses (per semester) and one practical course with Third Year Microbiology undergraduate students. The four theory courses they share are Medical Microbiology, Microbial Physiology, Microbial (prokaryotic and eukaryotic) Genetics and Immunology. The practical courses they share are 'Biochemistry and Molecular Biology' (Practical Course II) and 'Diagnostic Microbiology and Immunology' (Practical Course III) as per the existing version of the T.Y.B.Sc. Microbiology syllabus.

The courses for T.Y.B.Sc. Industrial Microbiology are structured to describe, explain and perform experiments related to Pollution Control Methods, Animal and Plant Tissue Culture, Validation of processes and methods and areas of Process Management and Economics.

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F. Y. B. Sc. Industrial Microbiology

Paper	Course Title	Marks	Lectures
Paper - I	Microorganisms and Systems for Fermentation Processes	100	Three Hours/Week per Paper (Total 36/Paper per Term)
Paper - II	Industrial Processes and Products	100	
Practical Course	Practical Course	100	*Four Hours / Week (Total 96 – Term I & II)
***Practical to be conducted as two hours each day on two consecutive days / Batch**			

Examination Pattern

Theory paper:	University Examination	– 80 marks (at the end 2nd term)
	Internal Examination	– 20 marks
Practical course:	University Examination	– 80 marks (at the end of 2nd term)
	Internal Examination	– 20 marks

Theory examination will be of three hours duration for each theory course. There shall be 5 questions each carrying equal marks. The pattern of question papers shall be:

Question 1	8 sub-questions, each of 2 marks; answerable in 2 -3 line and based on entire syllabus
Question 2 and 3	4 out of 6 – short answer type questions; answerable in 6 – 8 lines
Question 4	2 out of 4 – long answer type questions; answerable in 12 – 16 lines
Question 5	1 out of 2 – essay / long answer type question; answerable in 25 – 30 lines

Internal examination: Internal assessment of the student by respective teacher will be comprehensive and continuous, based on written test, 10 marks each term. The written test shall comprise of objective type questions – Multiple Types Questions, True / False, Definitions, Tricky computational problems with minimum calculations. There shall be 20 questions, each question of 0.5 marks.

Practical Examination: Practical examination shall be conducted by the respective college at the end of the academic year. Practical examination will be of minimum 4 hours duration, carried over on two subsequent days. There shall be 10 marks for laboratory log book and journal, 10 marks for viva-voce and minimum three experiments. Certified journal is compulsory to appear for practical examination. There shall be two experts and two examiners per batch for the practical examination.

Setting question papers: Questions should be designed to test the conceptual knowledge and understanding of the basic concepts of the subject.

S. Y. B. Sc. Microbiology

	Paper	Course Title	Marks	Lectures
Semester I	VOC-IND-MIC – 211	Bioreactors: Designs and Operation	50	Four Hours/Week per Paper (Total 48/Paper per Semester)
	VOC-IND-MIC – 212	Screening and Process Optimization	50	
Semester II	VOC-IND-MIC – 221	Fermentation Processes and Downstream Processing	50	
	VOC-IND-MIC – 222	Quality Assurance Tests for fermentation products	50	
Semester I & II	Practical Course	Practical Course	100	***Four Hours / Week (Total 96 – Semester I & II)
***Practical to be conducted as two hours each day on two consecutive days / Batch**				

Examination Pattern

Theory paper: University Examination – 40 marks (at the end of each semester)
Internal Examination – 10 marks
Practical course: University Examination – 80 marks (at the end of 2nd semester)
Internal Examination – 20 marks

Theory examination will be of two hours duration for each theory course. There shall be 4 questions each carrying equal marks. The pattern of question papers shall be:

Question 1	10 sub-questions, each of 1 marks; objective type and based on entire syllabus
Question 2 and 3	2 out of 3 sub-questions, each of 5 marks; short answer type questions; answerable in 10 – 15 lines
Question 4	1 out of 2 – long answer type questions; answerable in 20 – 25 lines

Internal examination: Internal assessment of the student by respective teacher will be comprehensive and continuous, based on written test, 10 marks each semester. The written test shall comprise of objective type questions – Multiple Types Questions, True / False, Definitions, Tricky computational problems with minimum calculations. Different sets of question papers may be given in the same class-room. There shall be 20 questions to be answered in 40 minutes, each question of 1mark.

Practical Examination: Practical examination will be of minimum 4 hours duration, carried over on two subsequent days. There shall be 10 marks for laboratory log book and journal, 10 marks for viva-voce and minimum three experiments. Certified journal is compulsory for appearing for practical examination. There shall be two experts and two examiners per batch for the practical examination. One of the examiners will be external.

Setting question papers: Questions should be designed to test the conceptual knowledge and understanding of the basic concepts of the subject.

T. Y. B. Sc. Microbiology

Theory Papers

	Paper	Paper Title	Marks	Lectures
Semester III	MB 331	Medical Microbiology – I	50	Four Hours/Week per Paper (Total 48/Paper per Semester)
	MB 332	Genetics & Molecular Biology - I	50	
	MB 333	Enzymology	50	
	MB 334	Immunology -I	50	
	VOC-IND-MIC – 335	Pollution Control Technology	50	
	VOC-IND-MIC – 336	Animal and Plant Tissue Culture	50	
Semester IV	MB 341	Medical Microbiology - II	50	
	MB 342	Genetics & Molecular Biology - II	50	
	MB 343	Metabolism	50	
	MB 344	Immunology -II	50	
	VOC-IND-MIC – 345	Molecular Biology and Recombinant DNA Technology	50	
	VOC-IND-MIC – 346	Microbial Process Management & Economics	50	

Practical Courses

	Course	Course title	Marks	
Semester III & IV	VOC-IND-MIC - 347	Based on Theory Courses: VOC-IND-MIC – 335, 336, 345 and 346.	100	***Four Hours / Week per course (Total 96/Course per Semester)**
	MB 348	Practical course – II Biochemistry & Molecular Biology	100	
	MB 349	Practical course – III Diagnostic Microbiology & Immunology	100	
***Practical to be conducted as four hours each day on three consecutive days / Batch**				

Examination Pattern

Theory paper: University Examination – 40 marks (at the end of each semester)
Internal Examination – 10 marks
Practical course: University Examination – 80 marks (at the end of 2nd semester)
Internal Examination – 20 marks

Theory examination will be of two hours duration for each theory course. There shall be 4 questions each carrying equal marks. The pattern of question papers shall be:

Question 1 – 10 sub-questions, each of 1 marks; objective type and based on entire syllabus
Question 2 and 3 – 2 out of 3 sub-questions, each of 5 marks; short answer type questions; answerable in 10 – 15 lines
Question 4 – 1 out of 2 – long answer type questions; answerable in 20 – 25 lines

Internal examination: Internal assessment of the student by respective teacher will be comprehensive and continuous, based on written test, 10 marks each semester. The written test shall comprise of objective type questions – Multiple Types Questions, True / False, Definitions, Tricky computational problems with minimum calculations. Different sets of question papers may be given in the same class-room. There shall be 20 questions to be answered in 40 minutes, each question of 1mark.

Practical Examination: Practical examination will be of minimum 6 hours duration, carried over on three subsequent days. There shall be 10 marks for laboratory log book and journal, 10 marks for viva-voce and minimum three experiments per practical course. Certified journals are compulsory for appearing for practical examination. There shall be two experts for each practical course and two examiners per batch; one of the examiners will be external.

Setting question papers: Questions should be designed to test the conceptual knowledge and understanding of the basic concepts of the subject.

Qualification of Teachers:

With minimum postgraduate degree in Microbiology (M. Sc. Microbiology) and qualified as per UGC regulations.

Course-wise details of the Syllabus

F. Y. B. Sc. Industrial Microbiology

Theory Paper I: Microorganisms and Systems for Fermentation Processes

Paper I: Term I

Topic	Description	(36)
I	**Scope of Industrial Microbiology:** *(Discussion should address atypical nature of Industrial microbiology to that with Chemical/any other industry, emphasis on functioning of fermentation industry by quoting examples of product and microbes)* • Definition and use of the term 'fermentation' • Industrial Microbiology and Biotechnology • History(An Art from the Past, a Skill for the Future) • Multidisciplinary nature • Obsolescence of procedures and methods • Organizational set-up in an industrial microbiology establishment, • Upstream processing (USP) and downstream processing (DSP), unit downstream processing • A Typical Bioprocess: introduction, advantages and limitations. • Industrial fermentation products and their producer microorganisms(List) • Patents and Intellectual Property Rights References: **Modern Industrial Microbiology and Biotechnology** (2007) by Nduka Okafor. Published by Science Publishers, Enfield, NH, USA Practical Fermentation Technology (2008) Edited by Brian McNeil and Linda M. Harvey, John Wiley & Sons, Ltd. ISBN: 978-0-470-01434-9	(10)
II	**Industrial Microorganisms:** • Taxonomic diversity of industrially useful bacteria and Fungi*(Brief Discussion on groups, their general feature and taxonomic position and Biotechnological uses)* • Characteristics important in microbes used in Industrial Microbiology and Biotechnology • Isolation of suitable producer microorganisms from the environment (Discuss approach for isolation) • Concept and examples of Microorganisms classified as Generally Regarded As Safe (GRAS) • Culture Collections of industrially important microorganisms • Industrial producer strains and strain improvement (Outline and importance of the process) • Use of mutants / Genetically Modified Microorganisms (GMM) as against Wild type isolates for production. • Aseptic and non-aseptic fermentations, • Fermentation types according to the organization of the biological system (Suspended and support culture) References: **Industrial Microbiology: An Introduction** (2001) by Michael J. Waites, Neil L. Morgan, John S. Rockey & Gary Higton **Modern Industrial Microbiology and Biotechnology** (2007) by Nduka Okafor. Published	(16)

	by Science Publishers, Enfield, NH, USA	
III	**Product development, regulation and safety** *(emphasis should be on the health care product development process and it's peculiarities in context with GMP,GMM, GLISP, QC,FDA, SOPs and validation)* • Development of a pharmaceutical product • Product quality and safety(Quality assurance components) • Manufacturing and environmental safety(World Health Organization's classification of microorganisms on the basis of hazard, Safety precautions required for different levels of containment) Reference: **Industrial Microbiology: An Introduction** (2001) by Michael J. Waites, Neil L. Morgan, John S. Rockey & Gary Higton	(10)

Paper I: Term II

Topic	Description	(36)
I	**Foundation for calculations in bioprocess engineering** *(emphasis on the numerical problem solving)* • Physical Variables, Dimensions and Units (Substantial Variables, Natural Variables, Dimensional Homogeneity in Equations, Equations Without Dimensional Homogeneity) • Units • Force and Weight • Measurement Conventions(Density, Specific Gravity, Specific Volume, Mole, Chemical compositions, Temperature and Pressure) • Standard Conditions and Ideal Gases • Physical and Chemical Property Data • Stoichiometry • Area / volume calculations Reference: **Bioprocess Engineering Principles** (1995) by Pauline M. Doran, Elsevier Science & Technology Books , ISBN: 0122208552	(10)
II	**Modelling the Kinetics of Biological Activity in Fermentation Systems** *(It is expected to emphasize skillful use of mathematics to address problems in fermentation)* • Basics of Modeling. • Need of Models. • Cyclic processes of model construction, verification and applications. • The Components of Modelling. • The Control Region (Volume), Variables, Parameters, Equations, **Reference:** Practical Fermentation Technology (2008) Edited by Brian McNeil and Linda M. Harvey , John Wiley & Sons, Ltd. ISBN: 978-0-470-01434-9	(12)

III	**Presentation and Analysis of Bioprocess Data:** *(It is expected to deliver the topic using numerical problems and exercises based on fermentation)* • Errors in data calculation(Significant figures, Absolute and relative uncertainty, types of error, statistical analysis,) • Presentation of experimental data(Tables, graphs and equations) • Data Analysis(Trends, Testing mathematical models, Goodness of fit: Least Square Analysis, Linear and Non-linear models) • Graph paper with logarithmic coordinates(Log-log plots, Semi-log plots) • General procedures for plotting data • Process flow diagrams **Reference:** **Bioprocess Engineering Principles** (1995) by Pauline M. Doran, Elsevier Science & Technology Books, ISBN: 0122208552	(14)

Suggested Reading:

1. Industrial Microbiology (1999) by Casida. LE, New age International (P) Limited, Publishers.
2. Industrial Microbiology (2000) by A.H. Patel. Macmillan Publishers India, *ISBN* 9780333908426
3. Principles of Fermentation Technology by P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heineman, Aditya Books (P) Ltd.
4. A text book of Industrial Microbiology (1989) by Wulf Crueger and Anneliese Crueger, Panimam Publishing Corporation.
5. Biology of Industrial microorganisms (1981) by Arnold L. Demain. Benjamin/Cummings Pub. Co., Advanced Book Program.
6. Biotechnology: a text book of industrial microbiology (1990); Wulf Crueger, Anneliese Crueger, Thomas D. Brock.
7. Batch Fermentation Modeling:Monitoring,and Control (2003) By Ali Cinar, Satish J. Parulekar Cenk Undey
8. Fundamental Principles of Bacteriology. 7th Edition (1971) by Salle A.J. Tata MacGraw Hill Publishing Co.
9. Microbial Biotechnology: Fundamentals of Applied Microbiology (2007), Second Edition, Alexander N. Glazer and Hiroshi Nikaido, Cambridge University Press.

F. Y. B. Sc. Industrial Microbiology

THEORY PAPER II: Industrial Processes and Products

Paper II: Term I

Topic	Description	(36)
I	Entrepreneurial overview of Biotechnology companies *(It is expected to discuss configuration and functioning of biotechnology companies with special emphasis on the factors that contribute to the success and failure of the companies.)* a. Concept of a biotechnology company b. Applications of biotechnology companies (Food, Agriculture, Medicine, etc.) c. Scientific creativity d. Market need e. The basic components of the companies (Infrastructure, Manpower, Hierarchical structure for overall management) f. How are the facilities integrated? g. Strategy to establish and run the company h. Competitive advantages i. Success j. Business plan k. Investment in biotechnology **Reference:** **Basic Biotechnology, 2nd Ed. (2001);** Colin Ratledge and Bjorn Kristiansen. Cambridge University Press, UK.	(15)
II	Designing Biotech Processes for commercial success *(It is expected to discuss the key steps involved in the development of fermentation process. An overview of the prerequisites, importance and the current practices for each step with suitable examples should be covered in the discussion.)* a. Product selection b. Strain Design and Selection c. Strain Improvement d. Criteria for Design and Optimization of a Fermentation Process **References:** **Bioreaction Engineering Principles, 3rd Ed. (2011);** John Villadsen, Jens Nielsen, Gunnar Lide´n, Springer Science+Business Media, USA **Industrial Microbiology: An Introduction (2001);** Michael J. Waites, Neil L. Morgan, John S. Rockey & Gary Higton. Blackwell Science Ltd., UK.	(06)
III	Process economics *(It is expected to discuss all the considerations for designing and costing of entire plant to create an economic awareness required for successful entrepreneurship. An overview of biotech company component assessment to estimate and calculate capital amount required to setup a biotech company with suitable example.)*	(15)

	a. Cost estimates b. Process design optimization c. Design exercise d. Capital costs estimates e. Operating costs estimates f. The costs case – to build or not to build **Reference:** **Basic Biotechnology, 2nd Ed. (2001);** Colin Ratledge and Bjorn Kristiansen. Cambridge University Press, UK.	

Paper II Term II

Topic	Description	(36)
I	Bioprocessing *(It is expected to discuss industrially important microorganisms, the raw materials and the suitable system in the development of any given fermentation process.)* a. Overall characterization of industrially important microorganisms *(An overview of industrial fermentation products and their producer microorganisms.)* b. Fermentation media and raw materials *(An overview of media components and raw materials of synthetic and/or natural origin being used in industrial fermentation processes. The process may include inoculums preparation, pilot-scale fermentations and main production fermentation.)* • Carbon sources • Nitrogen sources • Minerals, Vitamins and growth factors • Precursors • Inducers and elicitors • Inhibitors • Antifoams *c.* Fermentation systems *(An introduction to bioreactor design & construction, control of chemical & physical parameters, bioreactor control & monitoring and operating modes)* **References:** **Industrial Microbiology: An Introduction (2001);** Michael J. Waites, Neil L. Morgan, John S. Rockey & Gary Higton. Blackwell Science Ltd., UK.	(04)
	*Through Topic **II** to **X**, various contemporary fermentation products and processes are categorized in broader sense under various headings. It is expected to catalog the components such as microorganisms involved, raw material used, and fermentation process employed for production of such products and/or processes using suitable examples.* **References:** **Industrial Microbiology: An Introduction (2001);** Michael J. Waites, Neil L. Morgan, John S. Rockey & Gary Higton. Blackwell Science Ltd., UK. **Basic Biotechnology, 2nd Ed. (2001);** Colin Ratledge and Bjorn Kristiansen. Cambridge University Press, UK.	

II	Microbial enzymes a. Commercial microbial enzyme production b. Detergent enzymes c. Starch processing enzymes d. Enzymes in cheese production e. Enzymes in plant juice production f. Enzymes in textile manufacture g. Enzymes in leather manufacture h. Enzymes used in the treatment of wood pulps i. Enzymes as catalysts in organic synthesis	(04)
III	Fuels and industrial chemicals[1,3] a. Alkanes b. Butanol c. Industrial ethanol d. Polyhydric alcohols e. Hydrogen f. Electricity g. Amino acids h. Organic acids i. Polyhydroxyalkonates j. Microbial exopolysaccharides k. Bioemulsans	(04)
IV	Health care products[1,3] a. Antibiotics b. Ergot alkaloids c. Steroid biotransformation d. Bacterial vaccines e. Recombinant therapeutic peptides and proteins f. Bacteriophages as therapeutic agents g. Probiotics	(03)
V	Food and beverage fermentations[1,3] a. Alcoholic beverages b. Vinegar production c. Dairy fermentations d. Other traditional fermented foods	(03)
VI	Food additives and supplements[1,3] a. Flavors b. Lipids c. Natural food preservative d. Nucleosides, nucleotides and related compounds e. Vitamins b. Polysaccharides	(04)
VII	Microbial biomass production[1,3] a. Manufacture of baker's yeast b. Single cell protein production c. Mushrooms	(03)

VIII	Environmental biotechnology[1,3] a. Waste water and effluent treatment b. Composting c. Ensiling d. Biodegradation of xenobiotics e. Bioremediation f. Biomining (mineral leaching) g. Microbial desulphurization of coal h. Bioinsecticides	(04)
IX	Microbial biodeterioration of materials and its control[1,3] a. Biodeterioration of stored plant food materials b. Non-food animal products c. Stone and related building materials d. Cellulosic materials e. Fuels and lubricants f. Metals g. Plastics h. Biodeterioration of cosmetics and pharmaceuticals	(04)
X	Animal and plant cell culture[1,3] a. Monoclonal antibodies b. Shikonin production c. Alternatives to animal cell and plant cell culture	(03)

Further reading:

1. Industrial Microbiology by Casida. LE, New age International (P) Limited, Publishers.
2. Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.
3. Industrial Microbiology by A.H. Patel.
4. Principles of Fermentation Technology by P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heineman, Aditya Books (P) Ltd.
5. A text book of Industrial Microbiology by Wulf Crueger and Anneliese Crueger, Panimam Publishing Corporation.
6. Biology of Industrial microorganisms (1981); Arnold L. Demain.
7. Prescott & Dunn's Industrial microbiology (1987); G. Reed.
8. Modern Industrial Microbiology and Biotechnology (2007); Nduka Okafor.
9. Biotechnology: a text book of industrial microbiology (1990); Wulf Crueger, Anneliese Crueger, Thomas D. Brock.
10. Practical Fermentation Technology. Brian McNeil, Linda Harvey, Wiley.
11. Batch Fermentation Modeling: Monitoring, and Control. Authors: Ali Cinar; Satish J. Parulekar; Cenk Undey
12. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata MacGraw Hill Publishing Co.

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F. Y. B. Sc. Industrial Microbiology

Practical Course

(Term I & II)

Based On Theory Papers I & II		**(96)**
1	Laboratory discipline(Good Laboratory Practices)	(04)
2	Study of Bioreactor and its essential parts	(04)
3	Necessity and procedure of writing SOPs for instruments / equipment to be used in scale up and / or large scale production	(04)
4	Study of Biosafety cabinet	(04)
5	Assessment of efficiency of Biosafety cabinet	(04)
6	Study of fume-hood.	(04)
7	Microscopic observation of industrially important microorganisms using Light microscopy	(04)
8	Microscopic observation of industrially important microorganisms using Phase-contrast microscopy	(04)
9	Culturing and Characterization of microorganisms used in Dairy industry	(04)
10	Culturing and Characterization of microorganisms used in Agro-industry	(04)
11	Culturing and Characterization of yeast used in Bakery/distillery/winery	(04)
12	Culturing and Characterization of fungi used in pharmaceutical industry	(04)
13	Culturing and Characterization of actinomycetes used in pharmaceutical industry	(04)
14	Photo-documentation of industrially important microorganisms	(04)
15	Record-keeping for microbial cultures	(04)
16	Maintenance and Preservation of microorganisms-short term and long term	(04)
17	Retrieval and culturing of lyophilized cultures	(04)
18	Bio-burden estimation of Air	(04)
19	Bio-burden estimation of personnel body surfaces	(04)
20	Bio-burden estimation of raw material to be used in fermentation process	(04)
21	Design and use of typical fermentation process medium using crude raw material such as molasses and agro-waste	(08)
22	Isolation of microorganism from an environmental sample	(08)

Recommended Books:

1. Daniel Lim, Microbiology, 2nd Edition; McGraw-Hill Publication
2. Ingraham J. L. and Ingraham C.A. (2004). Introduction to Microbiology. 3nd Edition. Thomson Brooks / Cole.
3. Madigan M.T., Martinko J.M. (2006). Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc.
4. Michael J Pelczar, JR. E.C.S. Chan, Noel R. Krieg. (1993) Microbiology, 5th Edition, Tata MacGraw Hill Press.
5. Prescott L.M., Harley J.P., and Klein D.A. (2005). Microbiology, 6th Edition. MacGraw Hill Companies Inc.

6. Prescott, Lancing. M., John, P. Harley and Donald, A. Klein (2006) Microbiology, 6th Edition, McGraw Hill Higher Education
7. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata MacGraw Hill Publishing Co.
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