

# UNIVERSITY OF MUMBAI



## Revised Syllabus

Program – **Bachelor of Engineering**  
Course – **Biotechnology Engineering**  
(Final Year – Sem VII and VIII)

under

**Faculty of Technology**

(As per Credit Based Semester and Grading System from 2015-16)

## General Guidelines

### Tutorials

The number of tutorial batches can be decided based on facilities available in the institution.

Tutorials can be creative assignments in the form of models, charts, projects, etc.

### Term Work

Term work will be an evaluation of the tutorial work done over the entire semester.

It is suggested that each tutorial be graded immediately and an average be taken at the end.

A minimum of ten tutorials will form the basis for final evaluation.

Term work assessment has to be done based on the following:

Assignments: 20 Marks

Attendance: 05 Marks

For giving weightage to attendance, the following guidelines should be followed:

75% - 80%: 3 Marks, 81% - 90%: 4 Marks, Above 91%: 5 marks

### Theory Examination

In general all theory examinations will be of 3 hours duration.

Question paper will comprise of total six questions, each of 20 Marks.

Only four questions need to be solved.

Question one will be compulsory and based on as much of the syllabus possible.

**Note:** In question paper, weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus as far as possible.

### Practical Examination

A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

### Project & Seminar Guidelines

Project Groups: Students can form groups with not more than 3(Three).

The load for projects may be calculated as below,

Sem VII:  $\frac{1}{2}$  hr for teacher per group.

Sem VIII: 1 hr for teacher per group.

Maximum of four groups can be allotted to a faculty.

Seminar topics will be the consensus of the project guide and the students. Each student will work on a unique topic.

The load for seminar will be calculated as one hour per week irrespective of the number of students.

Students should spend considerable time in applying all the concepts studied, into the project. Hence, six hours are allotted in Project A, 8 hours in Project-B and three hours for Seminar.

# University of Mumbai

## Scheme for BE: Semester-VII

Subject Code	Subject Name	Teaching Scheme			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BTC701	Bioseparation & Downstream Processing Technology-I	04	–	01	04	–	01	05
BTC702	Bioprocess Modeling & Simulation	04	–	01	04	–	01	05
BTC703	Seminar	–	–	03	–	–	03	03
BTE704	Elective-II	04	–	01	04	–	01	05
BTP705	Project-A	–	–	06	–	–	03	03
BTL706	LAB VI	–	04	–	–	02	–	02
BTL707	LAB VII	–	04	–	–	02	–	02
<b>Total</b>		12	08	12	12	04	09	25

### Examination Scheme

Subject Code	Subject Name	Examination Scheme								
		Theory marks					Term Work	Pract.	Oral	Total
		Internal Assessment			End Sem. Exam					
		Test 1 (A)	Test 2 (B)	Avg. of (A) & (B)						
BTC701	Bioseparation & Downstream Processing Technology-I	20	20	20	80	25	–	–	125	
BTC702	Bioprocess Modeling & Simulation	20	20	20	80	25	–	–	125	
BTC703	Seminar	–	–	–	–	50	–	–	50	
BTE704	Elective – II	20	20	20	80	25	–	25	150	
BTP705	Project-A	–	–	–	–	50	–	50	100	
BTL706	LAB VI	–	–	–	–	–	25	–	25	
BTL707	LAB VII	–	–	–	–	–	25	–	25	
<b>Total</b>		60			240	175	50	75	600	

### Elective Streams(BTE704)

<b>Sem.VII</b>	<b>Elective II</b>	<ul style="list-style-type: none"> <li>● Food Biotechnology</li> <li>● Pharmaceutical Technology</li> <li>● Nanotechnology</li> </ul>
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Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTC701	Bioseparation & Downstream Processing I	4.0	1.0	5.0

### Prerequisites

Basics of Bioprocesses and Unit Operations  
 Basic knowledge of mass balance.  
 Concepts of molecular diffusion and diffusion coefficients

### Course Objectives

To cover the fundamentals, and design concepts of various downstream purification steps (unit operations) involved in a biochemical process.

### Course Outcomes

Students will be able to describe theory, principle, design, application and possible integrations of unit operations in bioprocessing

### Detail syllabus

Module	Contents	No. of hrs
1	<b>Introduction to Bioproducts and Bioseparation:</b> Range and characteristics of bioproducts Characteristics of Fermentation Broths Selection of unit operation with due consideration of physical, chemical and biochemical aspect of biomolecules Stages of Downstream Processing	06
2	<b>Product release and recovery processes:</b> Fundamental principles of obtaining the product from cell cultures intracellular vs. extracellular product Cell disruption-Physical, Chemical and Enzymatic methods of cell disruption Mechanical Cell disruption methods: High pressure Cell Homogenizer, Sonication	07
3	<b>Primary Separation:</b> Removal of insolubles and Biomass (and particulate debris) separation techniques Flocculation and sedimentation Centrifugation-Ultracentrifugation, Gradient centrifugation Filtration Theory of Filtration, Pretreatment of Fermentation Broths, Filter Media and Equipment, Conventional and Cross-flow Filtration, Continuous Filtration, Filter cake resistance, specific cake resistance, Washing and dewatering of filter cakes	12

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Module	Contents	No. of hrs
4	<b>Gas Absorption:</b> Solubility of gases in liquids, Effect of temperature and pressure on solubility, Ideal and Non-ideal solutions, Choice of solvent for gas absorption, absorption factor, stripping factor, minimum gas liq ratio, Single stage gas absorption- Cross Current, Co-current, Countercurrent, Multistage Counter current Operation. Absorption with Chemical Reactions Related problems	10
5	<b>Liquid-Liquid Extraction:</b> Introduction to Liquid-Liquid Extraction, Choice of Solvent for Liquid-Liquid Extraction Triangular coordinate system, Ternary Equilibria [Binodal Solubility Curve with effect of temperature and pressure on it], Single Stage Operation, Multistage Cross Current Operation, Multistage Counter Current Operation [with and without reflux] Equipments for liquid-liquid extraction. Kinetics and modeling of extraction cycles, Types of extraction processes: Reactive extraction, Aqueous two phase systems, Reverse micellar extraction, Liquid-liquid and solid-liquid extraction, Super critical fluid Extraction. Design of extraction equipment. Different types of extractors and designing of extractors. <b>Leaching:</b> Representation of equilibria, single stage leaching, multistage cross current leaching, multistage counter current leaching, equipments for leaching.	12
6	<b>Precipitation:</b> Protein Precipitation methods: Isoelectric precipitation, Salting out, Organic solvent addition, Non-ionic polymers, Polyelectrolyte Addition Selective denaturation of unwanted proteins Large scale precipitation Applications	05

## References

1. Treybal R.E. , Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. McCabe W.L. and Smith J.C., Unit operation in chemical engineering, 5 Ed., McGraw Hill New York 1993.
3. Geankopolis C.J., Transport processes and unit operations, Prentice Hall , New Delhi 1997.
4. Roger G. Harrison, Paul Todd, Scott R. Rudge, Demetri P. Petrides, Bioseparations Science and Engineering, Oxford University Press

5. B. Shivshankar, Bioseparations: Principles and Techniques, Eastern Economy Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012
6. Bioseparation & bioprocessing (2nd Ed.) 2-Volume set, Ed SUBRAMANIAN Ganapathy, Wiley-VCH, ( 09-2007)
7. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, WileyInterscience Publication, 1988.
8. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, Inc., 1986.
9. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.
10. Scopes Ak, Protein Purification, IRL Press, 1993
11. Biotechnology: Bioprocessing, Rhem and Reed, Vol. 3, 1993
12. Separation and purification techniques in biotechnology, Fredreich Dechow, 1989
13. Asenjo J.A. and J.Hong (Eds), Separation Processes in Biotechnolgy, Taylor and Francis
14. T. Schepler et al, Biotreatment, Downstream Processing and Modeling (Advances in Biochemical Engineering /Biotechnology, Vol 56) by Springer Verlag

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTC702	Bioprocess Modelling and Simulation	4.0	1.0	5.0

### Prerequisites

- Knowledge of Fundamental Laws of Physics
- Knowledge of basic Mathematics
- Knowledge of Reactors and its types
- Knowledge of production of various fermentation products

### Course Objectives

- To understand the mathematical models in Biochemical Engineering systems
- To learn about different aspects of modelling in Bioprocess system
- To learn various techniques to solve and simulate various bioprocess models

### Course Outcomes

- Students will be able to formulate model for biochemical System.
- Students will be able to solve Biochemical models

### Detail syllabus

Module	Contents	No. of hrs
1	Basic Modelling Principles: Introduction, definition of Modelling and simulation, different types of models, application of mathematical modelling, fundamental laws: continuity equation, energy equation, equation of motion, transport equation, equation of state, Phase and chemical equilibrium, chemical kinetics with examples	10
2	Mathematical Models for Biochemical Engineering Systems: Batch Reactor, CSTR isothermal with cooling/heating jacket or coil Continuous Stirred tank Bioreactor, Fed Batch reactor, Batch distillation	10
3	Numerical Methods: Solution of linear algebraic equations by cramer's rule, Gauss elimination, Gauss siedel iterative method Solution of Non algebraic equations by Bisection method, Newton Raphson, Secant Method Numerical integration: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Euler's method, Runga Kutta method Basic data analysis-curve fitting	12

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Module	Contents	No. of hrs
4	Modelling approaches for Biological systems Growth kinetic Models - structured and unstructured systems; Compartment models; Deterministic and stochastic approaches for modelling structured systems Thermal death kinetics models, Stochastic Model for thermal sterilization of medium	10
5	Modelling for activated sludge process, Model for anaerobic digestion, Model for lactic acid fermentation, antibiotic production, Ethanol fermentation	10

## References

1. J.E. Bailey and D.F. Ollis, Biochemical Engg Fundamentals, 1986, McGraw Hill Book Company
2. Said S.E.H. Elnashaie, Parag Garhyan, Conservation Equations and Modeling of Chemical and Biochemical Processes, 2003, Marcel Dekker
3. B. Wayne Bequette, Process Dynamics: Modeling, Analysis and Simulation, 1998, Prentice Hall
4. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002
5. Process Modelling, Simulation and Control for Chemical Engineers, by William Luyben, McGraw Hill, Second Edition.
6. Numerical Methods and Modelling for Chemical Engineers, Davis M.E. ,Wiley, New York 1984
7. Numerical Methods for Engineers, Santosh Kumar Gupta, Tata McGraw hill, 1995
8. Numerical Methods, M. K. Jain, S. R. K. Iyengar, and R. K. Jain Sixth Edition. New Age International Publishers, New Delhi, 2012
9. Introduction to Chemical Engineering Computing by Bruce A. Finlayson Wiley- International, 2005.

Course Code	Course/ Subject Name	Credits
BTS703	Seminar	3.0

### Details

Seminar topics will be the consensus of the project guide and the students. Each student will work on a unique topic.

Representation of seminar work can be in the form of presentation

Students shall present research articles which may or may not be related to the topic of their project.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTE704	Elective – II : Food Biotechnology	4.0	1.0	5.0

### Prerequisites

Basic concepts of Microbiology and Fermentation Technology

### Course Objectives

To impart knowledge of various areas related to Food science and technology

To enable the students to understand food composition and its physicochemical, nutritional and microbiological aspects

To familiarize the students about the processing and preservation techniques of Food products

### Course Outcomes

Students will know the principles of preservation

Students will understand the principles of food processing techniques and will be able to apply these principles to specific food commodities

### Detail syllabus

Module	Contents	No. of hrs
1	Introduction to food technology, Constituent of food, contribution to texture, flavour and organoleptic properties of food; food additives coloring agents, emulsifiers, preservatives, flavours, vitamins, organic acids and their functions; enzymes in food processing	08
2	Sources and activity of microorganisms associated with food; Factors affecting the growth and survival of micro-organisms in foods- intrinsic and extrinsic; Food borne diseases infections and intoxications, food spoilage causes. Microbial food- yeasts, bacteria and production of new protein foods - SCP, mushroom, algal proteins	10
3	Microbial fermentation and production of food and beverages using microorganisms. Pickling, Sauerkraut, vinegar, bread. Dairy product- Yogurt, cheese production by microbial and enzymatic(proteases) method. Alcoholic beverages- Beer(deoxygenating and desugaring by glucose oxidase of beer, beer mashing and chill proofing), Wine (red, white, sparkling), whiskey (Single Malt, Multi Malt), Vodka, Rum and Gin	10
4	Fermentation methods for preserving foods, Preparation of various food additives like coloring agents, emulsifiers, vitamins, flavours and organic acids	08

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Module	Contents	No. of hrs
5	Post Harvest technology for food crops. Food preservation-high temperature methods, low temperature methods, irradiation, high pressure method and chemical preservatives. Production of Fruit juices and types of Fruit juices	08
6	Food Packaging methods Materials used for food packaging of various food products like cheese, eggs, bread, alcoholic beverages, milk and juices	08

## References

1. Frazier, Food Microbiology, TI-IM Publications.
2. Heller, Genetic Engineering of Food: Detection of Genetic Modifications- Wiley Publications.
3. Le. A. et. Al., Microorganism & Fermentations- N.Y. Chemical
4. Rehm, Biotechnology Set Wiley Publications
5. M. R. Adams and M. O. Moss, Food Microbiology, Royal society of chemistry
6. James M. Jay, Modern food microbiology, An Aspen Publications
7. Prescott and dunn, Industrial microbiology, CBS Publications.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTE704	Elective – II: Pharmaceutical Biotechnology	4.0	1.0	5.0

### Prerequisites

Knowledge about biochemistry and biochemical pathways in biological systems

Knowledge about cell biology and metabolism

### Course Objectives

Student shall know about bioavailability, bioequivalence and factor affecting bioavailability.

Students shall know the pharmacokinetic and pharmacodynamic on the basis of CADD. They also know the design evaluation and application related to oral, parenteral, transdermal, implants, bioadhesives and targeted drug delivery systems.

### Course Outcomes

Students will be able to tell factors affecting the bioavailability and stability of dosage form. They also know the parameters for the disposition, absorption and Michaelis-Menton constants for non-linear kinetics.

Students will know the fabrication, design, evaluation and application of drug delivery systems.

### Detail syllabus

Module	Contents	No. of hrs
1	<b>Introduction To Pharmaceuticals:</b> History & Definition of Drugs. Sources of Drugs - Plant, Animals, Microbes and Minerals. Drug targets, Intermolecular bonding forces. Classification of Drugs Naming of Drugs and medicines	06
2	<b>Pharmacodynamics and Pharmacokinetics:</b> Molecules acting as drug targets Enzymes, Receptors, Nucleic acid, Miscellaneous (Transport proteins, lipids, carbohydrates) Three Phases of drug action Drug Absorption, Distribution, Metabolism and Excretion (ADME) Modes of drug administration Drug dosing (half-life, steady state concentration, drug tolerance, Bioavailability)	08
3	<b><i>In vivo</i> and <i>In vitro</i> approach of Drug discovery, design and development:</b> Drug discovery: finding a lead molecule Drug design: Optimizing target interaction	07

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Module	Contents	No. of hrs
4	<b>Final stages of drug development trials:</b> Preclinical and clinical trials Patenting and regulatory affairs	07
5	<b>Medicinal Chemistry:</b> Antibacterial, Anticancer, Antiviral drugs, Opioid analgesics	06
6	<b>Biopharmaceuticals:</b> Production of Therapeutic Proteins, Hormones, Cytokines - Interferons, Interleukins I & II, Tumor Necrosis Factor (TNF); Nucleic acids Role of Biopharmaceuticals in treatment of various health disorders	10
7	<b>Drug Delivery Systems, Biomaterials And Their Applications:</b> Controlled and sustained delivery of drugs. Biomaterial for the sustained drug delivery. Liposome mediated drug delivery. Drug delivery methods for therapeutic proteins.	08

## References

1. Biopharmaceuticals: Biochemistry & Biotechnology, Gary Walsh (1998), John Wiley & Sons Ltd.
2. Medicinal Chemistry by Graham L. Patrick, Oxford University Press
3. Remingtons Pharmaceutical sciences, (Mark Publications & Company eston PA ) year 1980.
4. Medicinal Chemistry: an introduction by Gareth Thomas, Wiley Publications
5. Theory & Practice of Industrial Pharmacy, (3rd ed.) Leon Lachman, Lea & Febiger (1986)

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTE704	Elective – II: Nanotechnology	4.0	1.0	5.0

### Prerequisites

Knowledge of Biophysics, Biochemistry, Molecular Biology, Immunology and Analytical Methods in Biotechnology

### Course Objectives

To develop the skills of the student in the area of Nanotechnology and its application.

To familiarize student with different techniques for synthesizing and characterizing of various nanoparticles.

To motivate and facilitate student to undertake the project and research work in Nanotechnology.

### Course Outcomes

At the end the student would have learned:

Students will have an in depth understanding of the components of Nanotechnology and the instruments used in Nanotechnology.

Students will be able to apply the concepts of Nanotechnology in various fields.

### Detail syllabus

Module	Contents	No. of hrs
1	<b>Basics and Scale of Nanotechnology:</b> Introduction, Scientific revolutions, Time and length scale in structures, Definition of a nanosystem, Dimensionality and size dependent phenomena, Surface to volume ratio-Fraction of surface atoms, surface energy and surface stress, surface defects, Properties at nanoscale (optical, mechanical, electronic, and magnetic)	09
2	<b>Different Classes of Nanomaterials:</b> Classification based on dimensionality, Quantum Dots, Wells and Wires, Carbon-based nano materials (buckyballs, nanotubes, graphene), Metalbased nanomaterials (nanogold, nanosilver and metal oxides), Nanocomposites, Nanopolymers, Nanoglasses, Nano ceramics, Biological nanomaterials	10
3	<b>DNA and Protein based Nanostructures:</b> DNA-gold particle conjugates, Polymer nanocontainers, Nanopores and nanomembranes for biochemical sensing, Micro and nanofluidic devices in biological studies, Peptide nanotubes and their applications electronics, antibacterial agents; protein self assembly, nanochips, nanopolymers	10

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Module	Contents	No. of hrs
4	<b>Nano-bioanalytics:</b> Luminescent Quantum Dots for Biological Labeling, Nanoparticle Molecular Labels Surface Biology: Analysis of Biomolecular Structure by Atomic Force Microscopy and Molecular Pulling-Force Spectroscopy, Biofunctionalized Nanoparticles for Surface Enhanced Raman Scattering and Surface Plasmon Resonance, Bioconjugated Silica Nanoparticles for Bioanalytical Applications	09
5	<b>Nanotechnology in Food, Medicine and Health Sciences:</b> Nanocomposites for food packaging, nanomaterials in cosmetics, Regenerative medicine - Nanostructured collagen mimics in tissue engineering, synthesis of nanodrugs, polymeric nanoparticle for Drug and gene delivery, Micelles for drug delivery, Nanotechnology in cancer research, Preparation of nanobiomaterials - Polymeric scaffolds collagen, Elastins, Mucopolysaccharides, proteoglycans, cellulose and derivatives, Dextrans, Alginate, Pectins, Chitin Toxicity and Environmental Risks of Nanomaterial	14

## References

1. Pradeep T., A textbook of nanoscience and nanotechnology , Tata Mcgrew Hill Education Pvt. Ltd., 2012.
2. Hari Singh Nalwa, Nanostructured Material and Nanotechnology, Academic Press, 2002
3. Niemeyer C. M., Bionanotechnology : Concepts, Application and Perspectives Wiley-VCH, 2006

Course Code	Course/ Subject Name	Credits
BTP705	Project-A	3.0

### Details

Project Groups: Students can form groups with not more than 3(Three).

Students should spend considerable time in applying all the concepts studied, into the project. Hence, six hours are allotted in Project A to the students.

Students are advised to take up industrial/ experimental oriented/ simulation and/or optimization based topics for their projects.

Students are expected to do research and literature survey for their topics and submit a synopsis at the end of the semester, specifying their hypothesised methodology and expected outcome of their work to be conducted in Project-B.

Students are also expected to present their synopsis at the end of the semester.

Course Code	Course/Subject Name	Credits
BTL706	LAB-VI	2.0

**Concepts for experiments:**

A minimum of 10 experiments must be performed based on the following concepts:

Viscometer

Cell disruption

Conventional filtration

Centrifugation

Distribution coefficient in Liq - liq extraction

Binodal curve in liq - liq extraction

Solid-liquid extraction of natural product and subsequent purification

Leaching

Protein precipitation and its recovery

Gas Chromatography

Ion Exchange Chromatography

Separation of Plant Pigments using Column Chromatography

Course Code	Course/Subject Name	Credits
BTL707	LAB-VII	2.0

**Concepts for experiments:**

A minimum of 10 experiments must be performed based on the following:

Material Balance without Reaction

Material Balance with Reaction

Energy Balance equations

Solving Linear equations

Solving Non linear algebraic equations

Parameter Estimation in kinetics

Modelling of Batch, Fed Batch and Continuous

Simulation of Batch Reactor

Simulation of Continuous Reactor

Solving Numerical integrations

Solving Algebraic equations

Solving Differential Equations

# University of Mumbai

## Scheme for BE: Semester-VIII

Subject Code	Subject Name	Teaching Scheme			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BTC801	Environmental Biotechnology	04	–	–	04	–	–	04
BTC802	Bioseparation & Downstream Processing Technology-II	04	–	–	04	–	–	04
BTC803	Bioprocess Plant & Equipment Design	03	–	01	03	–	01	04
BTE804	Elective-III	03	–	01	03	–	01	04
BTP805	Project-B	–	–	08	–	–	06	06
BTL806	LAB VIII	–	03	–	–	1.5	–	1.5
BTL807	LAB IX	–	03	–	–	1.5	–	1.5
<b>Total</b>		14	06	10	14	03	08	25

### Examination Scheme

Subject Code	Subject Name	Examination Scheme								
		Theory marks					Term Work	Pract.	Oral	Total
		Internal Assessment			End Sem. Exam					
		Test 1 (A)	Test 2 (B)	Avg. of (A) & (B)						
BTC801	Environmental Biotechnology	20	20	20	80	–	–	–	100	
BTC802	Bioseparation & Downstream Processing Technology-II	20	20	20	80	–	–	–	100	
BTC803	Bioprocess Plant & Equipment Design	20	20	20	80	25	–	–	125	
BTE804	Elective-III	20	20	20	80	25	–	–	125	
BTP805	Project-B	–	–	–	–	50	–	100	150	
BTL806	LAB VIII	–	–	–	–	–	25	–	25	
BTL807	LAB IX	–	–	–	–	–	25	–	25	
<b>Total</b>		80			320	100	50	100	650	

### Elective Streams(BTE804)

<b>Sem.VIII</b>	<b>Elective III</b>	<ul style="list-style-type: none"> <li>• Non Conventional Sources of Energy</li> <li>• Biosensor &amp; Diagnostics</li> <li>• Protein Engineering</li> <li>• Agriculture Biotechnology</li> </ul>
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Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTC801	Environmental Biotechnology	4.0	–	4.0

### Prerequisites

Knowledge of Biotechnological aspects and molecular genetics

### Course Objectives

The main objective of this course is to introduce to the students the current biotechnological approaches and technologies in the use of microbes and/or other organisms and their processes to improve environmental quality, clean up contaminated environment, renew resources and generate valuable products for human society.

### Course Outcomes

By studying this subject the students can be able to: Apply their knowledge of environmental science and biological systems to improve the quality of life in individual context.

Recognize key environmental problems and to apply the operating principles and biotic systems for remediation.

Design, improve and apply biotechnological systems and processes to meet practical needs of different environmental problems.

### Detail syllabus

Module	Contents	No. of hrs
1	<b>Introduction:</b> Environmental Degradation, types of environmental degradation, factors affecting environmental degradation, biogeochemical cycles (Nitrogen, Carbon, Oxygen, Phosphorus, Sulfur, Hydrological), pollution, pollutants and their types (general idea), Man induced impact on environment (Global warming, Green house effect, ozone depletion, acid rain, Photochemical smog), Environmental monitoring- sampling (land, air, water), analysis- physical, chemical, biological, pollution monitoring- bio indicators, biosensors, biomarkers, pollution control aspects	07
2	<b>Pollution control:</b> Pollutants, types, sources, effects, atmospheric stability, atmospheric dispersion- (Gaussian plume model), problems, air pollution control- Particulate and gaseous control, source correction methods, natural pathways of exchange of air pollutants from atmosphere to earth (wet precipitation- rain out, washout)	06

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Module	Contents	No. of hrs
3	<b>Water Pollution Control:</b> Pollutants, types, sources, effects, measurement of organic and inorganic pollutants, DO depletion, modelling of BOD reaction, problems on BOD, Methods of waste water treatment, Microbiology and design (activated sludge process, trickling process), Rotating Biological contactors, Fluidized bed reactors, anaerobic sludge digestion, Methanogenesis, methanogenic, acetogenic, fermentative bacteria- technical process and condition, waste water treatment using aquatic plants, heavy metal removal by hairy roots.	08
4	<b>Soil Pollution Control:</b> Pollutants, types, sources, effects, bioremediation of contaminated soil, types of bioremediation, factors affecting bioremediation, phytoremediation, role of genetic engineering	06
5	<b>Solid waste management:</b> Types of solid waste, sources, effects, methods of collection, disposal methods, potential methods of disposal, disposal of hazardous waste, Biological conversion process ( aerobic, anaerobic, bioventing), biotechnology applications to hazardous waste management	06
6	<b>Special topics in Bioremediation technology:</b> Nanotechnology for bioremediation of heavy metals, sulphate and sulphur reducing bacteria, bioremediation of petroleum sludge using bacterial consortium and biosurfactants	04
7	<b>Downstream Processing:</b> Downstream processing in biological treatment process, effluent disposal and reuse, biofiltration of waste gas, treatment and purification of biogas	04
8	<b>Effluent treatment:</b> Need of ETP in industry, Components of ETP, general design procedure for ETP, ETP studies of industries like dairy, metal, food etc.	05
9	<b>Environmental Legislations:</b> Water Prevention and Control Pollution Act, Water pollution act, Air pollution and prevention act, The environment Protection Act, Forest Conservation Act, Municipal Solid Waste Rules, Biomedical Waste Rules, Hazardous Waste Rules, Environmental Clearance, Environmental Legislation and Pollution Control Acts in India, Central Pollution Control Board, its functions and powers, Procedure to operate an industry	03

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Module	Contents	No. of hrs
10	<b>Environmental Standards:</b> Need and Use of environmental standards, Agencies and Bodies setting environmental standards, classification of environmental standards, National and International Standards for waste water	03

### References

1. Environmental Biotechnology- Allen Scragg, Oxford University Press, Second edition
2. Environmental Biotechnology, 1995 S.N. Jogdand, Himalaya Publishing House.
3. Bioremediation, 1994 Barker, K.H. and Herson, D.S., McGraw Hill, Inc. New York
4. Waste water Engineering, Metcalf & Eddy, Tata McGraw Hill Publication, Fourth edition
5. Environmental Science, Richard T. Wright, PHI Pvt. Ltd., Ninth edition
6. Environmental Pollution Health and Toxicology, S.V.S. Rana, Narosa Publishing House Pvt. Ltd., First edition

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTC802	Bioseparation & Downstream Processing II	4.0	–	4.0

### Prerequisites

Basics of Bioprocesses and Unit Operations  
 Basic knowledge of mass balance.  
 Concepts of molecular diffusion and diffusion coefficients

### Course Objectives

To cover the fundamentals, and design concepts of various downstream purification steps (unit operations) involved in a biochemical process.

### Course Outcomes

Students will be able to describe theory, principle, design, application and possible integrations of unit operations in bioprocessing

### Detail syllabus

Module	Contents	No. of hrs
1	<b>Adsorption and Ion Exchange:</b> Introduction to Adsorption, Types of Adsorption, Adsorption Isotherms, Single Stage Adsorption, Multistage Cross Current Adsorption, Multistage Counter Current Adsorption, Equipments for Adsorption Ion Exchange Equilibria, Ion Exchange Equipments Design and Construction of Chromatographic Columns for Bioseparations	10
2	<b>Membrane Separation Techniques:</b> Membrane separation processes: Reverse Osmosis, Ultrafiltration, Microfiltration, Nanofiltration, Dialysis, Electrodialysis, Gas Permeation, Pervaporation Types of Membranes, Membrane Modules and design Retention coefficient, Concentration Polarization, Membrane fouling Factors affecting membrane filtration Advantages of membrane separation processes over conventional separation techniques Industrial Applications	10

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Module	Contents	No. of hrs
3	<b>Equipments for Gas-Liquid Contacting applicable for Bioprocesses:</b> Classification of equipments for gas-liquid contacting, Gas dispersed and liquid continuous phase- Sparged Vessels (Bubble Columns), Mechanically Agitated Vessels, Tray Towers. Spray Towers and Spray Chambers, Packed Towers. Comparison of Packed Towers with Tray Towers.	06
4	<b>Crystallization:</b> Solubility curve, Super saturation, Method of obtaining super saturation Effect of heat on size and growth of crystal, Rate of Crystal growth and Delta-L law of crystal growth, Material and energy balance for crystallizers Crystallization equipment-description	08
5	<b>Drying:</b> Introduction to drying, Equilibrium, Different types of moisture contents, Rate of Drying and drying curve, Batch Drying and calculation of time of drying, types of driers Lyophilization Formulation	06
6	<b>Case Studies of downstream processing:</b> Baker's yeast, Ethanol, Citric acid, Penicillin, Insulin, Casein, interferon, cephalosporin, Recombinant Streptokinase, Monoclonal antibodies, Tissue plasminogen activator, Taq polymerase	12

## References

1. Treybal R.E. , Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. McCabe W.L. and Smith J.C., Unit operation in chemical engineering, 5 Ed., McGraw Hill New York 1993.
3. Geankoplis C.J., Transport processes and unit operations, Prentice Hall , New Delhi 1997.
4. Roger G. Harrison, Paul Todd, Scott R. Rudge, Demetri P. Petrides, Bioseparations Science and Engineering, Oxford University Press
5. B.Shivshankar, Bioseparations: Principles and Techniques, Eastern Economy Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012
6. Bioseparation & bioprocessing (2nd Ed.) 2-Volume set, Ed SUBRAMANIAN Ganapathy, Wiley-VCH, ( 09-2007)
7. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, WileyInterscience Publication, 1988.

8. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, Inc., 1986.
9. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.
10. Scopes Ak, Protein Purification, IRL Press, 1993
11. Biotechnology: Bioprocessing, Rhem and Reed, Vol. 3, 1993
12. Separation and purification techniques in biotechnology, Fredreich Dechow, 1989
13. Asenjo J.A. and J.Hong (Eds), Separation Processes in Biotechnolgy, Taylor and Francis
14. T. Schepler et al, Biotreatment, Downstream Processing and Modeling (Advances in Biochemical Engineering /Biotechnology, Vol 56) by Springer Verlag

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTC803	Bioprocess plant and Equipment Design	3.0	1.0	4.0

### Prerequisites

Process Calculation  
Unit operation I and II

### Course Objectives

To impart basic concepts of mechanical and process design of process plant..  
To impart design principles for bioreactor design.

### Course Outcomes

This course makes the students to learn the methods and practice followed in the design of Bioprocess equipments.  
This course makes the students to draw the designed equipments to scale.  
The course imparts advanced knowledge on bioreactor design for efficient utilization of the principles in bioprocess technology

### Detail syllabus

Module	Contents	No. of hrs
1	<p><b>Module 1:</b> Material of construction for process and bioprocess plants. Mechanical design of process equipment. Design of cylindrical and spherical vessel under internal and external pressure. Selection and design of enclosures- flat plate, formed heads, torispherical and hemispherical heads, standard flanges and nozzles- classification of flanges, flange thickness calculation, gasket selection and design, bolt selection and calculation (Numerical problems are not needed for design of flanges, gasket and nozzles) Design of heat exchange equipments for upstream and downstream operations in bioprocessing industries: Heat exchangers : process design (TEMA and IS 4503 standards) of double pipe, single pipe and multipass shell and tube heat exchangers.</p>	07
2	<p><b>Module 2:</b> Introduction to Indian Standards for storage tanks and their use in design of process vessel .Storage vessels for volatile and non volatile liquids including unfired pressure vessels. Design of supports- Bracket, leg, saddle and skirt support and fixed roof and open roof tanks.</p>	07

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Module	Contents	No. of hrs
3	<b>Module 3:</b> Development of flowsheet, piping and instrumentation diagram and its description. General design consideration, optimum design	07
4	<b>Module 4:</b> Detailed design and drawing of perforated plate distillation column. Absorption columns: Detailed design and drawing of perforated plate and packed towers.	06
5	<b>Module 5:</b> Design considerations for maintaining sterility of process streams and process equipments. Design of mechanically agitated fermenters and non-mechanically agitated (bubble column and air lift) fermenters.	06
6	<b>Module 6:</b> Design of various types of evaporators employed in bioprocess operation: Evaporators: Standard vertical tube evaporator, single and multiple effect evaporators and forced circulation evaporator. Thermal sterilization systems in fermentation processes: batch and continuous thermal sterilizers.	06

## References

1. Sinnott, R.K., Coulson & Richardson's 'Chemical Engineering', Volume 6, 3rd Edn., Butterworth Heinemann, New Delhi, 1999.
2. Perry, R.H., et al., Perry's 'Chemical Engineers Handbook', 7 th Edn., McGraw Hill, New York, 1997.
3. Joshi, M.V., and Mahajani, V.V., 'Process Equipment Design', 3 rd Edn., Macmillan India Limited, New Delhi, 1996.
4. Bownell, L.E., and Young, E.M., 'Process Equipment Design', Wiley Eastern, 1968.
5. Peters and Timmerhause, 'Plant Design and Economics for Chemical Engineers'
6. S.B. Thakore, B. I. Bhatt, 'Introduction to Process Engineering and Design', McGraw Hill Companies
7. Michael L Schuler and Fikret Kargi, 'Bioprocess Engineering' Printice Hall of India Pvt. Ltd
8. Pauline M Doran, 'Bioprocess Engineering Principles' Academic Press
9. Pressure vessel code-IS Code 2825, B.I.S., New Delhi, 1969
10. Heat Exchanger Design Code IS 4503, B.I.S., New Delhi, 1969
11. Process Equipment Design and Drawing by Kiran Ghadyalji, Nandu publication

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTE804	Elective – III : Non Conventional Sources of Energy	3.0	1.0	4.0

### Prerequisites

Knowledge of conventional sources of energy and energy utilization.

### Course Objectives

The main objective of this course is to introduce to the students the current approaches and technologies in the development of non-conventional sources of energy their processes to improve environmental quality and energy requirement, clean and abundant energy, renewable resources and generate cost efficient methods to harness energy for human society.

### Course Outcomes

Apply their knowledge of energy generation and its conservation to improve the quality of life in individual context.

Recognize key energy problems and to apply the operating principles and biotic systems for remediation.

Design, improve and apply biotechnological systems and processes to meet practical needs of different problems of energy requirement.

### Detail syllabus

Module	Contents	No. of hrs
1	<b>Introduction:</b> Traditional energy systems: fossil fuel, firewood, coal; Fossil fuel based systems, Impact of fossil fuel based systems; renewable and non-renewable sources of energy; global and national energy crisis, Prospects of renewable energy sources.	03
2	<b>Solar energy:</b> Solar energy : solar radiation spectrum, radiation measurements, applications (heating, cooling, drying, distillation); flat plate collectors, concentrating collectors, Solar air heaters-types, solar driers, storage of solar energy-thermal storage, solar pond, solar water heaters, solar distillation, solar still, solar cooker, solar heating & cooling of buildings, photo voltaics - solar cells & its applications	08
3	<b>Wind Energy:</b> Principle of wind energy conversion; analysis of aerodynamic forces acting on wind mill blades and estimation of power output; wind patterns and wind data; types of wind mills, components of wind mill, site selection.	03

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Module	Contents	No. of hrs
4	<p><b>Geothermal energy:</b> Estimation and nature of geothermal energy, geothermal sources and resources: hydrothermal, geo-pressured hot dry rock, magma; Advantages, disadvantages and application of geothermal energy; prospects of geothermal energy in India.</p>	03
5	<p><b>Energy from the Ocean:</b> Ocean Thermal Electric Conversion (OTEC) systems: open cycle, closed cycle, Hybrid cycle, prospects of OTEC in India.</p> <p>Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages, limitation and scope of tidal energy.</p> <p>Wave energy and power from wave, wave energy conversion devices, advantages and disadvantages of wave energy.</p>	05
6	<p><b>Energy from Biomass:</b> Biomass conversion principle: combustion and fermentation; Biogas generation plants: classification, advantages and disadvantages, constructional details, site selection, digester design consideration, filling a digester for starting, maintaining biogas production, Fuel properties of bio gas, utilization of biogas. Biodiesel: principle, production, efficiency, scope in India.</p>	05
7	<p><b>Fuel cells:</b> Introduction, Design principle, operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, application of fuel cells.</p> <p>Microbial Fuel cells: Principle, construction, working, efficiency and scope in India.</p>	03
8	<p><b>Hydrogen energy:</b> Introduction, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, utilization of hydrogen gas, hydrogen as alternative fuel for vehicles.</p> <p>Nuclear energy: nuclear reactors, fission and fusion reactions; advantages and disadvantages of nuclear energy.</p>	03
9	<p><b>Magneto Hydrodynamic (MDH) Power Generation:</b> Principle of MHD power generation, MHD system, Design problems and developments, gas conductivity, materials for MHD generators and future prospects.</p>	03
10	<p><b>Energy Management:</b> Energy economics, energy conservation, energy audit, general concept of total energy system, scope of alternative energy system in India.</p>	03

## References

1. Non-conventional energy sources by G.D. Rai, Khanna Publishers
2. Solar Energy: Fundamentals and Applications by H.P.Garg & Jai Prakash, Tata McGraw Hill
3. Solar Engineering of Thermal Processes by Duffie and Beckman, John Wiley
4. Solar Energy: Principles of Thermal Collection and Storage by S,P Sukhatme,Tata McGraw Hill
5. Alternative Energy Sources by B.L. Singhal Tech Max Publication
6. Non Conventional Energy Resources by S.Hasan Saeed and D.K.Sharma
7. Fuel Cells by Bockris and Srinivasan; McGraw Hill
8. Magneto Hydrodynamics by Kuliovsky and Lyubimov, Addison

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTE804	Elective – III: Biosensors and Diagnostics	3.0	1.0	4.0

### Prerequisites

Biochemistry , Analytical Methods In Biotechnology, Principles of Basic Instruments Used In A Biotechnology Lab.

### Course Objectives

The objectives of this course is that the students will be able to :

Explain the role of biological macromolecules as recognition elements & biosensors.

Describe the biomedical aspects of these sensors.

Analyse the interplay between materials, components and systems in the field of bio sensing.

Design an advanced biosensor for medical applications, using the current state of the art of biosensors.

Describe what challenges are shared among and what challenged are unique to the major biosensor application areas.

### Course Outcomes

By learning this course the students will be able to :

Apply the principles of engineering to the development of bioanalytical devices and the design of biosensors

Explain the principles of linking cell components and biological pathways with energy transduction, sensing and detection.

Differentiate among various biosensor systems.

Design a biosensor in response to agricultural, bioenvironmental, food safety, and biosecurity applications.

Apply engineering and biological approaches to solve problems in diagnosis of diseases, such as diabetes, cancer or detection of other analytes/biomarkers .

### Detail syllabus

Module	Contents	No. of hrs
1	Biosensors: Principles, Characteristics of Ideal Biosensors, Basic measuring procedure, Components of biosensors, Advantages & Limitations	09
2	Biocatalysis based biosensors, Bioaffinity based biosensors & Microorganisms based biosensors, Biologically active material and analyte. Types of membranes used in biosensor constructions.	10

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Module	Contents	No. of hrs
3	Various types of transducers, Principles and applications - Calorimetric, Optical, Potentiometric/ Amperometric, Conductrometric/ resistormetric.	05
4	Piezoelectric, Semiconductor, Impedimetric, Mechanical and molecular electronics based transducers, Chemiluminiscene-based biosensors.	05
5	Biosensors in clinical chemistry, Medicine and health care, Biosensors for veterinary, Agriculture and food, Low cost-biosensor for industrial processes for online monitoring , Biosensors for environmental monitoring.	10

## References

1. Roger, K.R. and Gerlach, C.L. 1 99. Update on environmental for biosensors.Env. Sci. Techno! 33 500A - 506A.
2. Bilitewski, U. Turner, A.P.F. 2000 Biosensors for environmental monitoring Harwood, Amsterdam.
3. Moses, V and Cape, R.E. 1991, Biotechnology the science and business,Harwood, Academic Publisher London
4. Rogers, K.R. and Mascini, M. 2001. Biosensors for analytical monitoring EPA biosensors group.
5. Aboul - Enein, H. V., Stefan, R. and Van Staden, (1999) Chemiluminiscence - based biosensors - An overview crit Rev. Anal. Chem. 29, 323-331.
6. Pearson, J.E. Gill, A., and Vadgama, P. (2000) Analytical aspects of biosensors ,Ann Clin Biochem 37, 119-145.
7. Biosensors: Fundamentals and applications, Oxford, U.K: Oxford University Press by Turner, A.P.F., Karube, I. & Wilson, GS.

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTE804	Elective – III: Protein Engineering	3.0	1.0	4.0

### Prerequisites

Principles of Biochemistry  
Principles of Recombinant DNA Technology  
Basics of Enzyme Activity

### Course Objectives

Imparting knowledge about structure function relationships of proteins  
Studying the problem of protein folding and methods of characterization folded proteins  
Aspects of Protein Engineering in the industry

### Course Outcomes

At the end the student would have learned:

Structure and Function relationship in proteins and its application in designing proteins  
Process of engineering proteins to increase its value by assisting folding, purification.  
Protein engineering of therapeutic proteins, industrially important enzymes and antibodies.

### Detail syllabus

Module	Contents	No. of hrs
1	<b>Structure of Proteins:</b> Post translational Modifications of proteins. Primary Structure and its determination Ramchandran Plot Secondary, Tertiary and Quaternary Structure of Proteins Bonds that stabilize a protein molecule Protein folding pathways and Energy Status of a Protein Molecule Protein Degradation in the cell	10
2	<b>Techniques involved in studying protein structure:</b> Methods of protein crystallization. Methods to study the quaternary structures of proteins: X-ray Crystallography, NMR Spectroscopy. MALDI-TOF, ESI-MS	07

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Module	Contents	No. of hrs
3	<b>Structure Function Relationships in Proteins:</b> Helix-turn-Helix motif in DNA binding and homeodomain protein. Zinc fingers. Leucine zippers. Membrane proteins: General characteristics, Transmembrane segments, bacteriorhodopsin and Photosynthetic reaction center	06
4	<b>Concepts of designing a new Protein Molecule:</b> Chemical synthesis of peptides. Target molecules for Protein Engineering. The protein cycle and steps involved in Engineering a new Protein. de novo protein design	06
5	<b>Applications of Protein Engineering:</b> Protein Engineering to enhance the solubility and assist folding of expressed proteins. Protein Engineering to assist purification of expressed proteins. Role in Vaccine Development. Engineering blood clotting factors: factor VIII. Engineering enzymes: tyrosyl-tRNA synthase. Engineering therapeutic hormones: insulin. Engineering humanized antibodies	10

## References

1. Lilia Arbenghina; Protein Engineering in Industrial Biotechnology; Harwood Academic Publishers
2. Creghton TE; Proteins Function, A Practical Approach; Freeman WH, Second Ed, 1993
3. Branden C. and Tooze J.; Introduction to Protein Structure; Second Edition, Garland Publishing, NY, USA, 1999
4. Moody PCE, and A.J.Wilkinson; Protein Engineering; IRL Press, Oxford, 1990
5. Walsh. G; Protein Biotechnology and Biochemistry; 2nd ed.; Wiley Publications
6. Klaus Demobowsky, Novel Therapeutic Proteins; Wiley Publications
7. Voet D. and Voet G.; Biochemistry' Third Edn. John Wiley and Sons, 2001

Course Code	Course/ Subject Name	Credits		
		Theory	Tut.	Total
BTE804	Elective – III: Agriculture Biotechnology	3.0	1.0	4.0

### Prerequisites

Knowledge about plant tissue culture methods and applications

Knowledge about genetic engineering methods for e.g. gene transfer techniques, plant vectors and basics of transgenic plants

Knowledge about traditionally used herbicides, pesticides, its advantages and drawbacks

Knowledge about ethical and biosafety issues and intellectual property rules associated with plants

### Course Objectives

To understand basic plant biology and breeding methods

To gain knowledge about transgenic plant analysis, principle behind generation of herbicide and pest tolerant plants

To understand the stress condition in plants and methods to overcome it

To design methods for crop improvement

To analyse applications based on molecular farming

### Course Outcomes

Students will be able to:

Apply the transgenic methods to develop better quality crops

Understand the advantages and drawbacks of engineered plants and modify them accordingly

Harness the plants for improved quality biomaterials

### Detail syllabus

Module	Contents	No. of hrs
1	<b>Agricultural Microbiology:</b> Microbial groups in soil, Plant and Microbe interactions. Plant pathogens. Biological nitrogen fixation. Microflora of Rhizosphere and Phyllosphere microflora, microbes in composting Beneficial microorganisms in Agriculture: Biofertilizer (Bacterial Cyanobacterial and Fungal), microbial insecticides, Microbial agents for control of Plant diseases	05

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Module	Contents	No. of hrs
2	<b>Plant Breeding:</b> Historical milestones in plant breeding. Aims and objectives of plant breeding, Significance of plant breeding in crop development. Concepts in plant breeding - Simple versus Complex Inheritance, Mating Systems, Varieties, and Pure Lines. Methods of Plant Breeding. Plant Hormone Signal Transduction - Auxin and GA Signaling, Cytokinin and Ethylene Signaling	07
3	<b>Transgenic Plants:</b> Transgenic Plant Analysis: screening on selection media, PCR, Intact Transgene Integration characterization, Real time PCR, Transgene expression, western blot analysis Regulations and Biosafety Field Testing of Transgenic Plants - Environmental Risk Assessment (ERA) process, e.g. the case of Bt Maize, Agronomic Performance, Risk analysis. Clean-gene technology .	05
4	<b>Genetic manipulation of herbicide tolerance:</b> The use of herbicides in modern agriculture Types of compounds used as herbicides Strategies for engineering herbicide tolerance - Glyphosate tolerance, Phosphinothricin, Prospects for plant detoxification systems Commercialization of herbicide-tolerant plants to date The environmental impact of herbicide-tolerant crops Development of Superweeds.	03
5	<b>Biotic and Abiotic stress:</b> Abiotic stress: Acclimation and crop adaptation to water stress, salinity stress, temperature stress, heat and cold, Photo oxidative stress, nutrient stress, heavy metal stress, metabolite engineering for abiotic stress tolerance Biotic stress: plant response to pathogens and herbivores, biochemical and molecular basis of host plant resistance, toxins of fungi and bacteria, systemic and induced resistance, pathogen derived resistance, genetic engineering for biotic stress resistance	08

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Module	Contents	No. of hrs
6	<b>Genetic manipulation of pest resistance:</b> The nature and scale of insect pest damage to crops. GM strategies for insect resistance: the <i>Bacillus thuringiensis</i> approach. The use of <i>Bacillus thuringiensis</i> as a biopesticide. Bt-based genetic modification of plants. Problem of insect resistance to Bt, environmental impact of Bt crops. Copy Nature strategy	03
7	<b>Improvement of crop yield and quality:</b> Genetic manipulation of fruit ripening, softening, genetic modification of ethylene biosynthesis. Golden rice and Biofortified rice. Engineering plant protein composition for improved nutrition. The genetic manipulation of crop yield by enhancement of photosynthesis	04
8	<b>Molecular farming:</b> Farming of carbohydrates (e.g. starch, polyfructans) Metabolic engineering of Lipids (e.g. Bioplastics) Molecular farming of proteins (e.g. oleosin system: hirudin and insulin production). Medically related proteins (e.g. custom made antibodies, Edible vaccines)	04

## References

1. Plant biotechnology -The genetic manipulations of plants by Slater, A., Scott, N. and Fowler, M., Oxford University press
2. Principles of Plant Breeding by Allard R W 1960 .Kalyani Publishers, New Delhi.
3. Plant Biotechnology and Genetics: Principles, Techniques, and Applications - Edited by C. Neal Stewart, Jr.
4. Stress biology, by U. Chakraborty, Bishwanath Chakraborty, 2005. Narosa Publishing House.
5. Agricultural Microbiology by D. J. Bagyaraj, G. Rangaswami, Prentice Hall of India Pvt Ltd.

Course Code	Course/ Subject Name	Credits
BTP805	Project-B	6.0

### Details

Project Groups: Students can form groups with not more than 3(Three).

Students should spend considerable time in applying all the concepts studied, into the project. Hence, eight hours are allotted in Project B to the students.

Students are advised to take up industrial/ experimental oriented/ simulation and/or optimization based topics for their projects.

Students have to submit a comprehensive thesis based on the research work conducted throughout the year.

Students are expected to present their work and defend their thesis.

Course Code	Course/Subject Name	Credits
BTL806	LAB-VIII	1.5

### Concepts for experiments:

A minimum of 10 experiments must be performed from the following list of experiments:

- Physical property like pH, turbidity, conductivity, alkalinity determination of waste water
- Determination of total phosphorus content of waste water
- Determination of total Kjeldahl Nitrogen of waste water
- Determination of BOD of waste water
- Determination of COD of waste water
- Determination of Oil and grease content of waste water
- Determination of total solids, total suspended solids and total dissolved solids
- Determination of MLSS and MLVSS
- Determination of Sludge Volume Index
- Estimation of metals like iron, copper in waste water
- Determination of chloride content of waste water
- Estimation of coliform bacteria in waste water
- Determination of phytoplankton in waste water
- Determination of Most Probable Number of waste water
- Removal of heavy metals by chemical methods from waste water Adsorption

Course Code	Course/Subject Name	Credits
BTL807	LAB-IX	1.5

**Concepts for experiments:**

A minimum of 10 experiments must be performed on the following concepts:

Adsorption

Membrane based filtration

Dialysis

Reverse Osmosis

Storage techniques for bioactive compounds- Freeze drying, Spray drying

Crystallization

Isolation and purification of biomolecules (protein/s or enzyme) from crude source/fermentation broth

Assessment of recovery and purity of the isolated product