UNIVERSITY OF MUMBAI

Bachelor of Engineering

Biotechnology (Second Year – Sem. III & IV), Revised course

(REV- 2012) from Academic Year 2012 -13,

Under

FACULTY OF TECHNOLOGY

(As per Semester Based Credit and Grading System)

From Dean's Desk:

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's) and course objectives and course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

Semester based Credit and Grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance.Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 3-2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

Credit and grading based system was implemented for First Year of Engineering from the academic year 2012-2013. Subsequently this system will be carried forward for Second Year Engineering in the academic year 2013-2014, for Third Year and Final Year Engineering in the academic years 2014-2015 and 2015-2016 respectively.

Dr. S. K. Ukarande

Dean,

Faculty of Technology,

Member - Management Council, Senate, Academic Council

University of Mumbai, Mumbai

Preamble to the Revision of Syllabus in Biotechnology

The onset of nineties brought about some paradigm shifts. One was in the sphere of market economics. Suddenly the Indian manufacturing sector started jostling for a place with international competition in the arena. The presence of International products at competitive rates and quality forced some small and medium scale units to close their operations. The larger industry players realized the importance of R&D and accordingly set up separate cells to optimize production and improve quality.

The second major impact was in the sphere of knowledge. With the advent of World Wide Web in the early nineties and its subsequent growth, the latest research trends have become accessible from drawing rooms across the globe. This acted as a positive feedback mechanism in increasing the pace of research in all fields including Chemical Engineering and Bio-technology. This was the motivation for an in depth analysis of what is actually required for today's technology. It is also important to take advantage of the freely available software to enhance the quality and quantity of material that can be covered in the class room.

With this scenario as the backdrop, the first meeting was conducted by Board of Studies in Chemical Engineering at Rizvi college of Engineering on 4th February 2013. It was attended by the various heads of departments of Biotechnology engineering as well as experts from industry.The program objectives and outcomes were thoroughly discussed in this meeting and the core structure of the syllabus was formulated. A second meeting was held in M.G.M College of Engineering on 5th of March 2013 to decide the subject experts and syllabus for the subjects of semesters III and IV.Finally the Board of studies meeting was conducted on 20th April 2013 at the Fort campus of University of Mumbai, where the final structure and detailed syllabus of Semesters III and IV were approved.

Dr. V. Ramesh

Chairman, Board of Studies in Chemical Engineering (Ad-hoc)

University of Mumbai, Mumbai

UNIVERSITY OF MUMBAI
SCHEME OF INSTRUCTION AND EXAMINATION
S.E: SEMESTER-III

Subject Code	Subject Name	Teaching Scheme (Contact Students)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BTC301	Applied Mathematics-III	3	--	1	3	--	1	4
BTC302	Microbiology	4	--	--	4	--	--	4
BTC303	Cell Biology	3	--	--	3	--	--	3
BTC304	Biochemistry	4	--	--	4	--	--	4
BTC305	Unit Operations-I	4	--	--	4	--	--	4
BTC306	Process Calculations	3	--	1	3	--	1	4
BTL307	Microbiology Lab	--	4	--	--	2	--	2
BTL308	Biochemistry Lab	--	3	--	--	1.5	--	1.5
BTL309	Unit Operations-I Lab	--	3	--	--	1.5	--	1.5
	Total	21	10	2	21	5	2	28

Subject Code	Subject Name	Examination Scheme								
		Theory								
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)	Term Work	Pract.	Oral	Total
		Test1	Test 2	Avg.						
BTC301	Applied Mathematics-III	20	20	20	80	03	25	--	--	125
BTC302	Microbiology	20	20	20	80	03	--	--	--	100
BTC303	Cell Biology	20	20	20	80	03	25	--	--	125
BTC304	Biochemistry	20	20	20	80	03		--	--	100
BTC305	Unit Operations-I	20	20	20	80	03	25	--	--	125
BTC306	Process Calculations	20	20	20	80	03	25	--	--	125
BTL307	Microbiology Lab	--	--	--	--	--	--	25	--	25
BTL308	Biochemistry Lab	--	--	--	--	--	--	25	--	25
BTL309	Unit Operations-I Lab	--	--	--	--	--	--	--	--	--
	Total	--	--	120	480	--	100	50	--	750

Student Contact Hrs Per week: 33

UNIVERSITY OF MUMBAI
SCHEME OF INSTRUCTION AND EXAMINATION
S.E: SEMESTER-IV

Subject Code	Subject Name	Teaching Scheme (Contact Students)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BTC401	Applied Mathematics-IV	3	--	1	3	--	1	4
BTC402	Molecular Genetics	3	--	1	3	--	1	4
BTC403	Fermentation Technology	4	--	--	4	--	--	4
BTC404	Analytical Methods in Biotechnology	4	--	--	4	--	--	4
BTC405	Immunology and Immunotechnology	4	--	--	4	--	--	4
BTC406	Unit Operations-II	4	--	--	4	--	--	4
BTL407	Fermentation Technology Lab	--	4	--	--	2	--	2
BTL408	Analytical Methods in Biotechnology Lab	--	3	--	--	1.5	--	1.5
BTL409	Unit Operations-II Lab	--	3	--	--	1.5	--	1.5
	Total	22	10	2	22	5	2	29

Subject Code	Subject Name	Examination Scheme							
		Theory Marks							
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)	Term Work	Pract.	Oral	Total
		Test1	Test 2	Avg.						
BTC401	Applied Mathematics-IV	20	20	20	80	03	25	--	--	125
BTC402	Molecular Genetics	20	20	20	80	03	25	--	--	125
BTC403	Fermentation Technology	20	20	20	80	03	--	--	--	100
BTC404	Analytical Methods in Biotechnology	20	20	20	80	03	--	--	--	100
BTC405	Immunology and Immunotechnology	20	20	20	80	03	25	--	--	125
BTC406	Unit Operations-II	20	20	20	80	03	25	--	--	125
BTL407	Fermentation Technology Lab	--	--	--	--	--	--	25	--	25
BTL408	Analytical Methods in Biotechnology Lab	--	--	--	--	--	--	25	--	25
BTL409	Unit Operations-II Lab	--	--	--	--	--	--	--	--	--
	Total	--	--	120	480	--	100	50	--	750

Student Contact Hrs Per week: 34

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.

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 maximum part of the syllabus.

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:

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for Practical Examination after completing 8 experiments out of 10 experiments in a Lab Course.

Project & Seminar Guidelines

- Project Groups: Students can form groups with minimum 2 (Two) and not more than 3 (Three)
- The load for projects may be calculated proportional to the number of groups, not exceeding two hours per week.
- Each teacher should have ideally a maximum of three groups and only in exceptional cases four groups can be allotted to the 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, eight hours each were allotted in Project A, B and three hours for Seminar to the students.

ANNEXURE -I
Program Structure for S.E. Biotechnology
Mumbai University

Semester III

Subject Code	Subject Name	Teaching Scheme (Contact Students)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BTC301	Applied Mathematics-III	3	--	1	3	--	1	4
BTC302	Microbiology	4	--	--	4	--	--	4
BTC303	Cell Biology	3	--	--	3	--	--	3
BTC304	Biochemistry	4	--	--	4	--	--	4
BTC305	Unit Operations-I	4	--	--	4	--	--	4
BTC306	Process Calculations	3	--	1	3	--	1	4
BTL307	Microbiology Lab	--	4	--	--	2	--	2
BTL308	Biochemistry Lab	--	3	--	--	1.5	--	1.5
BTL309	Unit Operations-I Lab	--	3	--	--	1.5	--	1.5
	Total	21	10	2	21	5	2	28

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract.	Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)				
		Test1	Test 2	Avg.						
BTC301	Applied Mathematics-III	20	20	20	80	03	25	--	--	125
BTC302	Microbiology	20	20	20	80	03	--	--	--	100
BTC303	Cell Biology	20	20	20	80	03	25	--	--	125
BTC304	Biochemistry	20	20	20	80	03		--	--	100
BTC305	Unit Operations-I	20	20	20	80	03	25	--	--	125
BTC306	Process Calculations	20	20	20	80	03	25	--	--	125
BTL307	Microbiology Lab	--	--	--	--	--	--	25	--	25
BTL308	Biochemistry Lab	--	--	--	--	--	--	25	--	25
BTL309	Unit Operations-I Lab	--	--	--	--	--	--	--	--	--
	Total	--	--	120	480	--	100	50	--	750

Course Code	Course/Subject Name	Credits
BTC301	**Applied Mathematics III**	**4**

Pre-requisites:

Basics of complex numbers: modulus, argument; equation of a circle, roots of unity, Euler's formula; hyperbolic functions; matrices: symmetric, orthogonal and unitary matrices, rank, normal form, solutions of systems of linear equations; basics of LPP: graphical method; calculus: partial derivatives, Hessian, maxima/minima of functions of 1 and 2 real variables.

Course Objectives:

- To introduce students to the basic methods of Laplace transforms.

- Laplace transforms and inverse Laplace transforms of all the standard functions.

- To enable students to solve initial value ODE problems using L-transforms.

- To study eigenvalues and eigenspaces of matrices.

- Orthogonal and congruent reduction of quadratic forms.

- Complex analysis: C-R equations, Milne-Thomson method.

- Bilinear transformations and cross-ratios.

- Introduction to statistics.

- Lagrange multiplier method for 2 and 3 variables with no more than two constraints.

- To introduce the basics of optimization using Kuhn-Tucker conditions.

Course outcomes:

- The student will be able to solve initial value ODE problems.

- The student will have a good understanding of real and complex analysis.

- The student will have a thorough grounding in matrix algebra.

- The student will be ready for any further courses on optimization.

Module	Contents	No. of Hrs.
01	The Laplace transform: Definition and properties (without proofs); all standard transform methods for elementary functions including hyperbolic functions; Heaviside unit step function, Dirac delta function; the error function; evaluation of integrals using Laplace transforms; inverse Laplace transforms using partial fractions and H(t-a); convolution (no proof).	07
02	Matrices: Eigenvalues and eigenspaces of 2x2 and 3x3 matrices; existence of a basis and finding the dimension of the eigenspace (no proofs); non-diagonalisable matrices; minimal polynomial; Cayley - Hamilton theorem (no proof); quadratic forms; orthogonal and congruent reduction of a quadratic form in 2 or 3 variables; rank, index, signature; definite and indefinite forms.	07
03	Complex analysis: Cauchy-Riemann equations (only in Cartesian co-ordinates) for an analytic function (no proof); harmonic function; Laplace's equation; harmonic conjugates and orthogonal trajectories (Cartesian co-ordinates); to find f(z) when u+v or u - v are given; Milne-Thomson method; cross-ratio (no proofs); conformal mappings; images of straight lines and circles.	07
04	Complex Integration Cauchy's integral formula; poles and residues; Cauchy's residue theorem; applications to evaluate real integrals of trigonometric functions; integrals in the upper half plane; the argument principle.	06
05	Statistics: (No theory questions expected in this module) Mean, median, variance, standard deviation; binomial, Poisson and normal distributions; correlation and regression between 2 variables.	05
06	Optimization (No theory) Non-linear programming: Lagrange multiplier method for 2 or 3 variables with at most 2 constraints; conditions on the Hessian matrix (no proof); Kuhn-Tucker conditions with at most 2 constraints.	07

References:

- Mathematical Methods in Chemical Engineering, V.G. Jenson and G.V. Jeffreys, Academic Press, 1970
- Laplace transforms, Murray Spiegel, Schaum's Outline Series, 1974
- Complex variables, Murray Spiegel, Schaum's Outline Series, 1964
- Linear Algebra, Murray Spiegel, Schaum's Outline Series, 1964
- Probability and Statistics: Murray R. Spiegel, Schaum's Outline Series, 1965
- Advanced Engineering Mathematics by *Erwin Kreyszig*, 9TH Edition, Wiley India.

Course Code	Course/Subject Name	Credits
BTC302	**Microbiology**	**4**

Prerequisites:

Basic Knowledge of Living Cells

Course Objectives:

- The course aims to develop skills of the Students in the area of Microbiology particularly to identify microbes, their structure, their metabolism and their industrial applications.
- They will study various sterilization techniques and their effects.
- This will be a prerequisite for all courses offered in Bioprocess Technology

Course outcomes:

- Students will be able to carry out various microbiological techniques like staining and isolation very well.
- They would be able to identify microbes.
- They would have detailed knowledge of various sterilization techniques, which would be useful for other courses

Module	Contents	No. of Hrs.
01	**History and Scope of Industrial Microbiology:** • Introduction: Discovery of Microbial world • The experiments of Pasteur; The discovery of Anaerobic Life • Physiological significance of Fermentation; Pasteur and Fermentation • The Era of discovery of Antibiotics; Growth of Industrial fermentation	07
02	**Classification of Micro organisms** • Types and general characteristics of microorganisms: 1) Bacteria- Archaebacteria, Actinomycetes, Rickettsia, Mycoplasma, Chlamydia 2) Fungi – Molds and yeasts 3) Algae 4) Protozoa 5) Viruses • The classification of bacteria Species: The unit of classification, New approaches to bacterial taxonomy, Bacterial taxonomy the problems of	08

	taxonomic arrangements, Bacterial phylogeny.	
	• Aerobic and Anaerobic cultures	
	Microbial Pathogenesis	
	• Epidemiology of infectious diseases, Bacterial, Fungal, Protozoal, Viral Diseases;	
	• Bacterial invasion and colonization	
	• Bacterial toxins- types and mode of action	
02	**Microbial Nutrition:**	06
	• Nutritional requirements of microorganisms	
	• Different types of media- Synthetic media, complex media Selective media, differential media, enrichment media.	
03	**Microbial Growth:**	04
	• Introduction: phases of growth	
	• Growth curve	
	• Kinetics of growth	
	• Measurement of growth	
	• Continuous & batch culture	
	• Synchrony	
	• Chemostat & turbidostat.	
	• Effects of solutes ,temperature ,ion concentration, oxygen, hydrostatic pressure ,heavy metal ions, and UV light on microbial growth	
04	**Microbiological Techniques:**	09
	• Sterilization and disinfection techniques,	
	• Principles and methods of sterilization.	
	• Physical methods - autoclave, hot-air oven, pressure cooker, laminar air flow, filter sterilization.	
	• Radiation methods – UV rays, gamma rays, ultrasonic methods.	
	• Chemical methods - Use of alcohols, aldehydes, fumigants, phenols, halogens and hypochlorites. Phenol coefficient.	
	• Isolation of pure culture techniques - Enrichment culturing, dilution-plating, streak- plate, spread-plate and micromanipulator.	
	• Preservation of microbial cultures - sub culturing, overlaying cultures with mineral oils, lyophilization, sand cultures, storage at low temperature.	
05	**Antimicrobial Therapy:**	08
	• Antimicrobial sensitivity tests.	
	• Agents used in treating infection: Antibacterial, antiviral, anti retroviral, antifungal, anti-protozoan & anti helminthes.	
	• Resistance mechanism.	
06	**Water & Soil Microbiology:** Microbiological analysis of water purity-sanitary tests for coliforms (presumptive test, confirmed test, competed test), MPN test, defined substrate test, IMVIC test.	10
	• Soil microbiology- soil as a habitat for microorganisms, physico-	

		chemical properties of soil, microbial community in soil, role of microorganisms in organic matter decomposition.	

References:

1. Textbook of Microbiology ;R. Ananthnarayan, C. K. J. Panicker, Orient Longman 6th Edition (2003)

2. General Microbiology, R.Y. Stanier, J.L. Ingraham, M.L.Wheelis and P.R. Painter, Macmillian

3. Microbiology VI Edition, M.J. Pelczar, E.C.S. Chan and N.R. Kreig, Tata McGraw Hill Microbiology by Prescott

4. Microbiology: An Introduction (9th Ed.) by Tortora GJ, Funke BR, and Case CL, Pearson Education, 2008.

5. Industrial Microbiology, Casida, New Age International

6. Industrial Microbiology, Prescott and Dunn, C.B.S. Publishers Principles of Microbiology, R.M. Atlas, WMC.Brown Publisher.

7. Microbiology – Fundamentals and Application, 6th Ed. – Purohit, S.S. (Agrobios)

8. Textbook of Microbiology, P.Charkborthy

9. General Microbiology Vol. II by Powar and Daginawala Himalaya Publ. House 8th edition (2004)

Course Code	Course/Subject Name	Credits
BTC303	Cell Biology	3

Prerequisites:

- Knowledge of basic terminology of cell and cell organelles

- Knowledge of structure and function of prokaryotic and eukaryotic cell

- Knowledge of different compartments of cell organelle.

- Knowledge of cell division

- Basic knowledge of cell events like photosynthesis, respiration

Course Objectives:

The cell is the fundamental unit of all life. In this course, we will explore the great diversity of all cellular form and function. Course emphasis is placed on the molecular mechanisms of cell metabolism, growth, division, and communication. This course is central to the cell biology and serves as the bridge between foundational courses in the cell and advanced courses in the complexity of sorting in the cell

Course Outcome:

- By the end of the course students should be able to grasp the fundamentals in Understanding the molecular organization of the cells, function and structure of The different organelles including transport mechanisms for processes like; Protein sorting, cell communication and flow of information and transport across the unit membrane, cell signaling**.**

- Students will have good knowledge of cancer, its types and etiology.

  Students will be able to appreciate all basic concepts which he may encounter in future courses in biotechnology engineering.

- Students will be ready for application of these concepts in the field of research in biotechnology.

Module	Contents	No. of Hrs.
1	**Cytology:** • Development history of cytology. • Cell – basic unit of life: Structure and function of cell, • Prokaryotic & Eukaryotic cell • Structure and function of various cells such as Viruses, Bacteria, Animals • Cell division and cell cycle	05
2	**Concept of Cyto-receptors:** • Function of membrane receptors. • Methods of introduction of substances to cells: endo and excocytosis, pinocytosis, phagocytosis. • Mechanism of transport substances through membrane: • diffusion • osmosis • ion channels • active and passive transport • ion pumps	06
3	**Structural organization and mechanism of sorting and regulation of intracellular transport, electrical properties of membranes:** • Cell wall, nucleus • Mitochondria • Golgi bodies • lysosomes • endoplasmic reticulum, • structure & function of cytoskeleton and its role in motility	06
4	**Cell signaling:** • Hormones and their receptors • cell surface receptor • signaling through G-protein coupled receptors • signal transduction pathways	05

	• second messengers, and regulation of signaling pathways	
5.	**Cellular communication:** • General principles of cell communication, • cell adhesion and roles of different adhesion molecules, • gap junctions • desmosomes • tight junction • extracellular matrix, integrins • neurotransmission and its regulation	06
6.	**Pathogenecity of cell:** • Living cells Vs dead cell • Necrotic Vs pycnotic death • Prgrammed cell death • Regeneration of cell	05
7	**Cancer:** • Types of tumors • Molecular basis of cancer. • Characteristics of growing tumor cells: general and morphological changes, biochemical changes, Metastasis, Apoptosis.	06

References:

1. Cell and Molecular biology, Gerald Karp, John Wiley and sons Inc
2. Cell Biology by C.B. Powar.
3. Cell and Molecular Biology; DeRobertis; Lippincott Williams & Wilkins 8th Edition (2001)
4. Molecular Biology of the Cell and the Hypercell with CDROM; Alberts, Bray; Garland Publishing 1st Edition (1999)
5. Molecular Biology of the Cell with CDROM Alberts, Bruce; Johnson, Alexander; Lewis, Julian 4th Edition (2005).
6. Molecular Cell Biology, H. Lodish, A. Berk, S. L. Zipursky, W. H. Preeman and Compa

Course Code	Course/Subject Name	Credits
BTC304	Biochemistry	4

Prerequisites:
- Knowledge of organic chemistry: functional groups and their reactions
- Knowledge of living cell and its components

Course Objectives:
- The major objective is to provide complete understanding of all the chemical processes associated with living cells at the molecular level.
- To ensure students have a strong grounding in structures and reactions of biomolecules.
- To introduce them to the metabolic pathways of the major biomolecules.
- To correlate biochemical processes with biotechnological applications.

Course outcomes:

The students will be able to understand and analyze the correlation between biomolecules, their associated pathways and various biological processes underlying the living systems.

Module	Contents	No. of Hrs.
1	• Introduction, aims and scope • Chemical foundations of Biology- Properties of water, acids, bases and buffers, covalent bonds, Non-covalent interactions in biological systems.	05
2	**Biomolecules:** Classification, Structure and Functions of : • Carbohydrates: • Lipids • Proteins • Nucleic acids	14
3	**Enzymes**	05

		• Working of Enzymes • Concept of Activation energy and transition state • Factors affecting enzyme activity- pH, Temperature, Substrate & Enzyme Concentration	
4	**Vitamins and Hormones** Vitamins: Classification, functions, role in metabolism, vitamins as cofactors. Hormones: Classification, endocrine glands, function and mechanism of action of hormones.		05
5	**Metabolism** • Carbohydrates- Glycolysis, TCA cycle • Lipids- Digestion by GI enzymes and breakdown of Triglycerides: α, β, ω oxidation of fatty acids • Amino acids- decarboxylation, deamination & transamination. Urea cycle; fate of amino acids (connection to TCA) • Electron Transport Chain • Photophosphorylation- Photosystems, reaction centers, pigments, cyclic and non-cyclic photophosphorylation, Z pathway		18
6	**Bioenergetics:** • Laws of Thermodynamics • Concept of Enthalpy, Entropy • Energy rich compounds – ATP as energy currency		05

References:

1. Nelson, D.L. and M.M. Cox, "Lehninger's Principles of Biochemsitry", 4th Edition, W.H. Freemen & Co., 2005.
2. Murray, R.K., etal "Harper's Biochemistry", 23rd Edition, Prentice Hall International, 1993
3. Lubert Stryer. 2007. *Principles of Biochemistry*. Freeman.
4. Voet and Voet. 2005. *Biochemistry*. Wiley.
5. D. Skoog, D.West, F.Holler, S.Crouch "Fundamentals of Analytical Chemistry" 8th Edition, 2004. Thomson Brooks/ Cole
6. David T. Plummer, An Introduction to practical biochemistry, Tata McGraw Publishing Company Ltd.

Course Code	Course/Subject Name	Credits
BTC305	**Unit Operations – I**	**4**

PREREQUISITES:

Basic knowledge in physics, units and dimensions and thermodynamics

Course Objectives:

- To impart the basic concepts of fluid statics and dynamics
- To study the basic equations of fluid flow.
- They should be comfortable with measurement of pressure or pressure drop.
- To enable students to determine viscosity using method such as Stokes Law.
- To study the different types of size reduction equipments used in Industries.
- To study about the metering and pumping of fluids.

Course Outcomes:

- The student will have a thorough grounding on measurement of pressure drop, velocity, flow rates etc. of fluids.
- They can select pumps and would be able to calculate power requirement for pumping as well as agitation operations.
- They will be able to operate certain flow measurement devices and size reduction equipments.

Module	Details	No of Hrs.
01	**Intoduction:** Classification of fluids, Rheological behavior of fluids & Newton's Law of viscosity. Effect of temperature & pressure on viscosity of fluids. **Fluid statics**: Pascal's law ,Hydrostatic equilibrium,Barometric equation and pressure measurement(problems)	05
02	**Fluid Dynamics:** Continuity Equation, , Equation of motion, Euler's equation of motion,Bernoulli's equation(problems),Bernoulli's equation for compressible fluids(isothermal and adiabatic process)concept of Reynold's number,Laminar flow in pipes, Turbulent flow in pipes, velocity and shear stress distribution across pipe,Boundary layer	08

		formation and seperation of boundary layer.	
03	**Flow of Incompressible fluids:**Relationship between skin friction and wall shear,Fanning friction fractor,friction factor law for smooth pipes,Form friction,effect of roughness, energy relationships,pipe fittings,major and minor losses in pipe flow. **Flow measurements**: Venturimeter, Orificemeter, Pitot tube, Rotameter. **Pumping**: Reciprocating pumps, Rotary pumps, centrifugal pumps(Characteristics,NPSH,Cavitation) and blowers.		09
04	**Particle Size distribution**: Importance of particle size in reactions, particle size, shape and mass distributions,measurement and analysis, concept of average diameter. **Screening:-**Screening equipment, capacity and effectiveness of screen, effect of mesh size on capacity of screen. Particle size analysis:- mean diameter, derived diameter. Sieving -cumulative method and differential method. **Transportation and storage of solids** : Studies performance and operation of different conveyor systems like Belt, Screw, Apron, Flight, pneumatic conveyor and elevators; Storage of solids and discharge pattern from storage bin.		12
05	**Size Reduction** : Factors affecting size reduction, comminution laws : Kick's law, Rittinger's law and Bond's law and their limitations. Crushing efficiency & power consumption **Size reduction equipments** : Grinder – Construction and operation of Hammer mill, Ball mill, Ultrafine grinder – Fluid energy mill, Cutting machines: knife cutters,		09
06	**Separation based on particle Mechanics through liquids** : Free settling and Hinderd settling, Stoke's law & Newton's law regimes of settling. Clarifiers and thickeners, flocculation, batch sedimentation(Kynch theory), rate of sedimentation. **Filtration:**Theory and principle of solid liquid filtration, cake filters, discontinuous pressure filter: principle and working of filter press. **Mixing & Agitation:** Principles of agitation, agitation equipment, Solid solid mixing equipment,Mixing effectiveness and Mixing index. Flow patterns in Agitated vessels,Impellers,Types of impellers,power consumption of Impellers.		09

Text books

1. McCabe, W.L, Smith J.C and Harriot, P., "Unit Operations in Chemical Engineering", McGrawHill, FourthEdition, 1984.

2. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 2, Third Edition, Pergamon Press, 1977..

References

1. Badger and Bencharo, " Introduction to Chemical Engineering". TMH,

2. Narayanan C.M.& Bhattacharya B.C. "Mechanical opeartions for chemical engineers", Khanna.

3. 3.R.S.Hiremath & A.Kulkarni. Mechanical Operations Vol. I.

4. Fluid Mechanics and Hydraulics by Suresh Ukarande, Ane Books, 2012.

Course Code	Course/Subject Name	Credits
BTC306	**Process Calculations**	**4**

Prerequisites:

- Linear Algebra
- Differential Equation

Course Objectives:

- To study the laws regarding gas ,liquid and vapour
- To develop understanding about material balance and energy balances
- To study the stoichiometry and thermodynamics of microbial growth and product Formation

Course outcomes:

- The student will be able to understand basic application of various unit operations &unit processes to industrial &theoretical problems
- They will have a clear understanding of the various systems of units will be able to do the conversion of units of one system to another.
- They will be able to do basic calculations for biological systems & access the property data from appropriate sources.

Module	Contents	No. of Hrs.
01	Units and dimensions: Systems of units, fundamental and derived units, unit conversions, dimensional homogeneity and dimensional analysis- problems.Conversion of units	08
	Chemical arithmetic: Mole concept, atomic weight, molecular weight and equivalent weight- methods of determination.	
	Chemical composition: Methods of expressing compositions of mixtures and solutions- mole percent, mass percent, volume percent, molarity, molality, normality etc.	
	P-V-T behaviour of pure liquids- Gas laws, real and ideal gases, equation of state, critical properties, properties of gas	
	mixtures- Dalton's laws, Amagat's law-Average molecular weight and density- problems.	

	Biochemical stoichiometry: Limiting and excess reactants- conversion, degree of completion, selectivity, yield problems.	
02	Fundamentals of material balances- Law of conservation of mass- Types of material balances, material balance with recycle bypass and purge streams-	08
03	Material Balance for process involving chemical reaction, Calculations using Psychrometric chart; Humidity and saturation	07
04	Fundamentals of energy balances, Law of conservation of energy, Heat capacity, sensible heat, latent heat, calculation of enthalpy changes. General energy balance equation; Energy balance calculations with and without reactions, Energy balance for fermentation and downstream processing- problems.	08
05	Stoichiometry of microbial growth and product formation, Growth Stoichiometry and elemental balances, respiratory quotient, degree of reduction, Yield and maintenance coefficients, Oxygen consumption in aerobic microbial cultures.Theoretical Oxygen demand- problems. Biochemical energetics: Metabolic reaction coupling, energetics of metabolic processes (respiration and biosynthesis) Transport across cell membranes, Thermodynamics of microbial growth, Heat generation in microbial cultures problems.	08

References:

1. David M.Himmelblau. 1989. Basic Principles and Calculations in Chemical Engineering. Prentice Hall of India (P) Ltd.

2. A.Hougen, K.M.Watson and R.A.Ragatz. 1970. Chemical Process Principles, Part - I, John Wiley and Asia Publishing Co.

3. Bhat B.I and S.M.Vora, 2005. Stoichiometry. Tata McGraw Hill.

4. Richard Felder and Ronald W.Rausseau. 1986. Elementary Principles of Chemical Processes. John Wiley & Sons.

5. Doran P.M, Bioprocess Engineering Principles, Academic Press

6. Bailey G.E and Ollis D.F, Bioprocess Engineering Fundamentals McGraw Hill

7. Shuler M.L and Kargi F, Bioprocess Engineering- Basic Concepts, Pearson Education

8. Segel I.H, Biochemical Calculations, John Wiley

9. Blanch H.W and Clark D.S, Biochemical Engineering Marcel Dekker Inc.

Course Code	Course/Subject Name	Credits
BTL307	**Microbiology Lab**	**2**

List of Experiments Suggested:

1. Study of different equipments- Bunsen burner, water bath, Autoclave, Laminar air flow, Incubator, Hot air oven, Centrifuge, and Refrigerator.

2. Study of Microscope- Compound Microscope & its parts. Use of oil Immersion objective.

3. Preparation of liquid medium -nutrients broth, nutrient agar, agar slant.

4. Staining: Simple, Differential staining methods, Capsule, Endospore; Study of shape and arrangement of bacterial cells

5. Isolation of microorganism by Pure Culture Techniques.

6. Effect of disinfectants on microbial flora

7. Isolation and identification of microorganisms from different sources – soil, water and milk

8. Antibiotic sensitivity assay

9. Effect of different parameters on bacterial growth (pH, temperature & UV irradiation)

10. Culture of aerobic & anaerobic bacteria

11. Effect of TDP & TDT on bacterial growth

12. Filter paper disc methods for evaluation of antiseptics

13. Study of growth curve of Ecoli

14. Bacterial colony counting using Haemocytometer

Course Code	Course/Subject Name	Credits
BTL308	**Biochemistry Lab**	**1.5**

List of Experiments Suggested:

1. Preparations of solutions –molar, normal, ppm, percent

2. Study of pH meter and preparation of buffers

3. Study of Beer and Lambert's Law and absorption maxima

4. Glucose estimation by DNSA method

5. Protein estimation by Biurette Test

6. DNA estimation by DPA method

7. RNA estimation by Orcinol method

8. Estimation of Vitamin C by Iodometry

9. Extraction and separation of plant pigment by paper chromatography

10. TLC of Fatty acids

11. Study of Enzyme Activity

12. Estimation of Lipids

Course Code	Course/Subject Name	Credits
BTL309	**Unit Operations - I Lab**	**1.5**

List of Experiments Suggested:

1. Viscosity by Stoke's Law

2. Venturimeter

3. Orificemeter

4. Flow through Helical coil

5. Reynold's Apparatus.

6. Bernoulli's apparatus

7. Sieve analysis

8. Screen effectiveness

9. Major and Minor losses

10. Ball mill

11. Hammer mill

12. Sedimentation

13. Centrifugal pumps

14. Vacuum Filtration

Semester IV

Subject Code	Subject Name	Teaching Scheme (Contact Students)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
BTC401	Applied Mathematics-IV	3	--	1	3	--	1	4
BTC402	Molecular Genetics	3	--	1	3	--	1	4
BTC403	Fermentation Technology	4	--	--	4	--	--	4
BTC404	Analytical Methods in Biotechnology	4	--	--	4	--	--	4
BTC405	Immunology and Immunotechnology	4	--	--	4	--	--	4
BTC406	Unit Operations-II	4	--	--	4	--	--	4
BTL407	Fermentation Technology Lab	--	4	--	--	2	--	2
BTL408	Analytical Methods in Biotechnology Lab	--	3	--	--	1.5	--	1.5
BTL409	Unit Operations-II Lab	--	3	--	--	1.5	--	1.5
	Total	22	10	2	22	5	2	29

Subject Code	Subject Name	Examination Scheme							
		Theory Marks					Term Work	Pract.	Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)				
		Test1	Test 2	Avg.						
BTC401	Applied Mathematics-IV	20	20	20	80	03	25	--	--	125
BTC402	Molecular Genetics	20	20	20	80	03	25	--	--	125
BTC403	Fermentation Technology	20	20	20	80	03	--	--	--	100
BTC404	Analytical Methods in Biotechnology	20	20	20	80	03	--	--	--	100
BTC405	Immunology and Immunotechnology	20	20	20	80	03	25	--	--	125
BTC406	Unit Operations-II	20	20	20	80	03	25	--	--	125
BTL407	Fermentation Technology Lab	--	--	--	--	--	--	25	--	25
BTL408	Analytical Methods in Biotechnology Lab	--	--	--	--	--	--	25	--	25
BTL409	Unit Operations-II Lab	--	--	--	--	--	--	--	--	--
	Total	--	--	120	480	--	100	50	--	750

Course Code	Course/Subject Name	Credits
BTC401	**Applied Mathematics IV**	**4**

Prerequisites:

Vector Calculus:- Multiple Integral, Partial differentiation, basic knowledge of vectors and their products,Knowledge of spherical and cylindrical coordinate system.

Partial Differential Equation:- Integration, Know2ledge of partial derivatives.

Course Objectives:

The syllabus/module aims to introduce the above topics (to the Learner) so as to equip the learner with mathematic tools to effectively model, analyze and find the solution of various problems in Chemical Engineering processes.

One can use vector formation and calculus together to describe and solve many problems in two/three dimension. The Fourier Transform and PDE module does the ground work for the techniques required to solve and find the answer for various physiochemical problems.

Course Outcomes:

It is expected that the learner will develop the proactive approach towards the selection of methods to a solution of Chemical Engineering problems coming across while studying higher level of Chemical Engineering .(Example: Flow of Liquid through Pipes/Gases etc.)

Module	Contents	No. of Hours
01	**Fourier Series** Expansion of functions in any interval (a, b) . Half range expansion; Complex form; Parseval's identity theorem; Orthogonal and Orthonormal functions. NO PROOFS REQUIRED.	09
02	Fourier Integrals and Fourier Transform; sine & cosine Integrals, sine & cosine transforms, complex transforms. NO PROOFS REQUIRED.	10
03	**Partial Differential Equations** Elliptic, Parabolic & Hyperbolic Equations; Laplace's equation; One dimensional Heat & Wave Equation, Two Dimensional	10

	wave equation. (ONLY NUMERICAL PROBLEMS. NO PROOFS REQUIRED).	
04	**Vector Integration** Green's Theorem in the plain; Conservative &Solenoidal Fields. Gauss Divergence Theorem, Stokes' Theorem. (ONLY NUMERICAL PROBLEMS. NO PROOFS REQUIRED).	**10**

References:

- Advanced Engineering Mathematics by *Erwin Kreyszig*, 9TH Edition, Wiley India.
- Schuam's outline series in Fourier series.
- Schuam's outline series in partial differential equations.
- Partial differential equations Vol 1 by Rutherford Aris.

Course Code	Course/Subject Name	Credits
BTC402	**Molecular Genetics**	**4**

Prerequisites:

- Knowledge of Cell and its components
- Knowledge of Biomolecules and their functions
- Knowledge of Cellular Metabolism

Course Objective:

- Understand the Central Dogma of gene expression
- Explain the foundations of Mendelian genetics and chromosomal theory and apply these, with appropriate terminology, to contemporary concepts in genetics.
- Understand the redundant and universal qualities of the genetic code and how it is used to determine the amino acid sequence of a polypeptide.
- Describe the processes of transcription and translation in both prokaryotes and eukaryotes at the molecular level.
- Describe how prokaryotes control their gene expression through positive and negative regulatory mechanisms.

Course outcome:

The major objective of the paper is to provide knowledge of molecular biology and genetics of Prokaryotic and eukaryotic organisms to the students. This paper provides insight on Replication, Transcription and translation processes in prokaryotes and eukaryotes, various mutations, their Repair mechanisms and cancer genetics.

Module	Contents	No. of Hrs.
01	**Structure of Nucleic Acid:** • DNA, RNA: mRNA,tRNA, rRNA, • Denaturation and Renaturation of DNA, • Tm; GC content from Tm, • Renaturation kinetics of DNA • Complexity of DNA, Cot curves • Satellite DNA: Repetitive DNA, SNP, STR	04
02	**Mendelism and its extensions** • Law of segregation • Law of independent assortment • Chromosomal basis of segregation and independent • Assortment	08

	- Linkage - Crossing over - Multiple allelism - Pleiotropy - Recombination **Cytogenetics** - International System for Human Chromosome Nomenclature - Mechanisms of numerical and structural chromosomal aberrations - Chromosomal basis of sex determination - Non-chromosomal basis of sex determination; mutations	
03	**DNA Replication:** - Prokaryotic and eukaryotic DNA replication, - Mechanism of DNA replication - Enzymes and accessory proteins involved in DNA replication. - DNA Damage Mechanism - DNA Repair Mechanism	07
04	**Transcription** - Prokaryotic transcription - Eukaryotic transcription - RNA polymerases, - General and specific transcription factors - Regulatory elements and mechanisms of transcription regulation, 5'-Cap formation - Transcription termination - 3'-end processing and polyadenylation, Post-transcriptional gene silencing RNA splicing - Nuclear splicing: splice some - Group I and group II introns - tRNA splicing - Alternate splicing	07
05	**Translation** - Prokaryotic and eukaryotic translation: - Synthesis of aminoacyl tRNA - Aminoacylsynthetases - Mechanism of initiation, elongation and termination - Regulation of translation, co-and post-translational modifications of proteins	07
06	**Regulation of gene expression** - Induction and repression, - Operon theory, lac operon, trp operon, ara operon - Attenuation - Positive and Negative Control - Catabolite repression - Regulation of transcription by cAMP and CRP	06

References:

1) Molecular Biology; David Freifelder, Narosa Publishing House,2nd edition (2004)

2) Microbial Genetics; David Freifelder, Narosa Publishing House, 2nd edition(2004)

3) Principles of Gene Manipulations; S. B. Primrose, R. M. Twyman, R. W. old, Blackwell Science,6th Edition (2003)

4) Gene VIII; Benjamin Lewin; Oxford Univ. Press, 8th edition (2004)

5) Advanced Molecular Biology; R. M. Twyman, 1st Edition, (2003)

6) Instant Notes on Molecular Biology; P.C. Turner, A. G. Mclennan, A. D. Bates & M. R. H. White, 2nd Edition (2002)

Course Code	Course/Subject Name	Credits
BTC403	**Fermentation Technology**	**4**

Prerequisites: Knowledge of microbiology

Course Objectives: To gain broad knowledge on

- Role of microorganisms in fermentation
- The various fermentation technologies used
- Production of important products through fermentation

Course Outcomes:

- Appreciate the use of microorganisms for the production of value added commodities.
- Understand the working of a fermentation system.
- To describe key industrial bioprocesses, from the traditional to the recently evolved.
- Integrate biological and engineering principles involved in the production and recovery of commercial products.
- Develop critical thinking skills and learn to employ a quantitative, scientific approach towards conversion of biological materials to value added products.

Module	Contents	No. of hrs.
01	**Introduction to fermentation** History and development of fermentation, general requirements of the fermentation, range of fermentation processes, parts of a fermentation process- upstream and downstream processing, aerobic and anaerobic fermentation, solid state and submerged fermentation.	04
02	**Introduction to Microbial Growth Kinetics** Batch culture (Quantifying cell concentration, Growth patterns and Kinetics), Continuous culture, Comparison of batch and continuous cultures in industrial processes, Fed batch culture, Examples of use of fed batch cultures.	05
03	**Isolation, preservation and improvement of industrial microorganisms** • Isolation methods utilizing selection of the desired characteristics • Isolation methods not utilizing selection of the desired characteristics • The preservation of industrially important microorganisms • Improvement of industrial microorganisms	09

	• The selection of induced mutants synthesizing improved levels of products • The use of rDNA techniques	
04	**Regulatory Mechanisms controlling the catabolic and anabolic pathways of microbes** Induction, carbon catabolite repression, crab tree effect, feedback inhibition and repression	03
05	**Media for industrial fermentations & sterilization** Introduction, Typical media, Energy sources, Carbon sources, Nitrogen sources, Buffers, Oxygen requirements, Antifoams, Medium optimization, Medium sterilization: The design of batch sterilization processes, The design of continuous sterilization processes, Sterilization of the fermenter, feeds and air, Filter sterilization	07
06	**The development of inocula for industrial fermentations** The development of inocula for yeast , bacterial and fungal processes, The aseptic inoculation of plant fermenters	04
07	**Aeration and agitation** The oxygen requirements and supply of industrial fermentations, Determination of KLa, Factors affecting KLa values, The balance between oxygen supply and demand	05
08	**Design of fermenter** Basic function of a fermenter for microbial or animal cell culture, body construction, various parts of a fermenter	04
09	**Important products through Fermentation** Organic acids: citric and acetic acid; enzymes : amylase, protease, lipase; antibiotics: penicillin; vitamins: vitB12; aminoacids: lysine, Glutamic acid ; organic solvents: ethanol, acetone butanol; alcoholic breverages: wine, beer; biomass : bakers yeast ; biofertilizers; biopesticides; biosurfactant; steroid transformation;biopolymers	11

References:

1. Principles of Fermentation Technology – Stanbury P.F., Whitaker A, Hall S. J.

2. Bioprocess Engineering: Basic concepts – Shuler M.L., Kargi F. (PHI)

3. Bioprocess Engineering Principles – Doran Pauline M. (Elsevier Pub.)

4. Biotechnology: A textbook of Industrial Microbiology- Cruger, W. and A. Cruger

5. Introduction to Biochemical Engineering - DG Rao, 2005, Tata McGraw-Hill, New Delhi

Course Code	Course/Subject Name	Credits
BTC404	**Analytical Methods In Biotechnology**	**4**

Pre-requisites:

1) Basic knowledge of Physical and Analytical Chemistry
2) Knowledge of various types of spectra
3) Knowledge of Biomolecules and their properties

Course Objective:

- To study the various analytical techniques used in Biotechnology.

Course outcomes:

- The students will be capable of handling different instruments in the laboratory.

- They would be able to compare different separation techniques and use them effectively in research work

Module	Contents	No of Hrs.
01	**Centrifugation:** - General principle- sedimentation velocity, sedimentation equilibrium - Types of centrifuges, preparative and analytical centrifugation, differential centrifugation, density gradient methods - Applications	08
02	**Chromatographic Techniques:** - Introduction to chromatography, General principles - Planar Chromatography: Thin layer chromatography, paper chromatography - Column chromatography–columns, stationary phases. Packing of columns, application of sample, column development, fraction collection and analysis. - Partition chromatography, Adsorption chromatography Affinity Chromatography, Ion Exchange Chromatography, Chromatofocussing, Size exclusion chromatography. - Gas Chromatography, HPLC: Principle & Components: pumping systems, detectors systems - Applications	14

03	**Electrokinetic methods of separation:**	13
	• Electrophoresis: General principle, factors affecting electrophoresis – voltage, current, resistance, buffer, composition, concentration, pH. • Agarose Gel electrophoresis • SDS-PAGE - gradient gels • Two dimensional gel electrophoresis • Isoelectric focusing • Capillary electrophoresis • Immunoelectrophoresis	
04	**Spectroscopy:**	09
	• Spectroscopic Techniques; Beers Lamberts law, molar and extinction coefficient, limitations of Beers Lamberts law. • Visible and UV Spectrophotometry; Principles, Instrumentation and applications	
05	**Radioisotopic techniques:**	08
	• Use of radioisotopes in life sciences, radioactive labeling, principle and application of tracer techniques • Detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger-Muller and Scintillation counters, Autoradiography • Applications	

References:

1. Wilson K and Goulding K.H., A biologist's guide to Principles and Techniques of Practical Biochemistry.

2. Willard and Merrit, Instrumental Methods and Analysis

3. Ewing GW, Instrumental Methods of Chemical analysis.

4. Robert. M. Silverstein et al, Spectrometric identification of Organic Compounds, 7th Edition, 1981.

5. Vogel's, Text Book of Quantitative Chemical Analysis, 6th Edition, 2004.

6. John A. Adamovic, Chromatographic Analysis of Pharmaceuticals, 2nd Edition.

7. Raymond P. W. Scott, Techniques and Practice of Chromatography –Vol. 70.

8. Sethi P.D, Dilip Charegaonkar, Chromatography –2nd Edition.

9. Niessen W. M. A., Van Der Greef J, Liquid Chromatography– Mass Spectrometry, Vol. 58.

10. Kalsi.P.K, Spectroscopy of Organic Compounds.

11. Hanes, Gel Electrophoresis of Proteins- A Practical Approach,

12. Hamilton R. J. and Sewell P. A, Introduction to High Performance Liquid Chromatography

13. Gordon M. Message, Practical aspects of Gas Chromatography and Mass Spectrometry, John Wiley and Sons, New York. 1984

14. Chapman J.M and G.Ayrey, The use of radioactive isotopes in the life sciences, George Allen and Unwin Ltd., London.

Course Code	Course/Subject Name	Credits
BTC405	**Immunology and Immunotechnology**	**4**

Prerequisites:

- Knowledge of anatomy and physiology of human body
- Knowledge of blood components and blood cells
- Knowledge of lymphatic system
- Knowledge of principle of immune response and vaccine
- Knowledge of history and basic terminology in immunology

Objectives

- To learn about various basic terminology in immunology
- To have knowledge of immune system in detail
- To describe the interaction of antigens and antibodies in antibody mediated and cell-mediated immune responses.
- To make familiar with the techniques involved in antigen and antibody reactions
- To understand the concepts and principle of immunoassay techniques in routine diagnosis, research
- To learn principle and types of vaccines

Outcomes:

- Student can define innate and adaptive immunity
- Student can define the characteristics of antigens
- Student can define the characteristics of antibodies
- Student can describe cellular cooperation in antibody and cell mediated immune responses
- Student can define antigen antibody interaction
- Student can describe Production of Monoclonal Antibodies and Recombinant Vaccines.

Module	Contents	No. of Hrs.
01	**Introduction to immune system** • Innate and adaptive immunity • Cells and organs of the immune system • Primary and secondary immune responses; • Cell mediated and humoral response	09

02	**Antigens & Antibodies**	07
	• Antigens	
	• Antibodies and T cell receptors: Antigens, Structure and function of immunoglobulins,	
	• B and T cell receptors and co-receptors	
03	**Generation and regulation of immune responses**	10
	• Antigen processing and presentation	
	• MHC-restriction; Cytokines	
	• T Cell Maturation, activation andDifferentiation B Cell Generation, activation and differentiation	
	• Clonal selection and immunological memory	
	• Complement system, classical ,alternative and MBL pathway	
	• Cell mediated cytotoxic responses	
	• Regulation of immune responses; Immunological tolerance	
04	**Antigen-antibody Reactions**	10
	• Strength of Antigen-Antibody Reactions	
	• In Vivo Antigen-Antibody Reactions, In Vitro Antigen-Antibody Reactions	
	• Precipitation (In Fluid and In Gel Immunoelectrophoresis),	
	• Agglutination (Heamagglutination, Bacterial agglutination, Passive agglutination and Agglutination Inhibition).	
	• Radio immuno Assay (RIA)	
	• Enzyme Linked Immunosorbant Assay (ELISA),	
	• Western Blot	
	• Immune Fluorescence	
05	**Disorders of Human Immune System**	07
	Primary and secondary immunodeficiency; Autoimmune disorders; Hypersensitive reactions; Cytokine related diseases	
06	**Production of Monoclonal Antibodies and Recombinant Vaccines.**	09
	• Monoclonal antibody, polyclonal antibody. Production of monoclonal antibodies - Definition, production, applications.	
	• Recombinant Vaccines - Definition, recombinant vector vaccines, DNAvaccines ,Multivalent subunit vaccines ,minicell vaccines,conjugate vaccines	

References:

1. Essential Immunology: Ivan Roitt.
2. Kuby Immunology: Golds by, Kindt and Osborne.
3. Immunology: Roitt, Brostoff, Mole.
4. Introductory Immunology : Huw Davies

Course Code	Course/Subject Name	Credits
BTC406	**Unit Operation - II**	**4**

Pre-requisites:

An understanding of differential equations and basic physical concepts, units and dimensions

Course Objectives:

- To study the basics of Heat and Mass Transfer

- To develop understanding about the application of Heat and Mass transfer in Bioprocessing.

- To calculate the size of heat transfer equipments, for a known quantity of raw material.

- To apply energy balance.

- To understand the role of diffusion, drying &distillation in the processes. To apply material balance.

- To design equipments in which heat &mass transfer occurs.

Course outcomes:

- The student will be able to understand basic application of various unit operations &unit processes to industrial &theoretical problems

- They will have a clear understanding of the theories of Heat and Mass transfer which are used for modeling.

- They will be able to do design the fermenter and Bioreactors using the models developed.

Module	Contents	No of Hrs.
01	Introduction: Various modes of heat transfer Viz. Conduction, Convection and Radiation. Conduction: Fouriers law, Steady state unidirectional heat flow through single and multiple layer slabs, Cylinders and spheres for constant and variable thermal conductivity. Insulation: Properties of insulation materials, Types of insulation, Critical and Optimum thickness of insulation. Extended Surfaces: Fins – Types of fins, Derivation of fin efficiency for	08

		longitudinal fins, Fin effectiveness. Elementary treatment of unsteady state heat conduction. Problems	
02		Convection: Individual and overall heat transfer coefficient, LMTD, LMTD correction factor.	09
		Dimensionless numbers, - Dimensional analysis, Empirical correlation for forced and natural convection.	
		Analogy between momentum and heat transfer – Reynolds, Coulburn and Prandtl analogies. Problems	
		Heat Transfer with Phase Change: Boiling phenomena, Nucleate and film boiling, Condensation – Film and Drop wise condensation, Nusselts equations.	
03		Radiation: Properties and definitions, Absorptivity, Reflectivity, Emissive power and intensity of radiation, Black body radiation, Gray body radiation, Stefen – Boltzmann law, Wien's displacement law, Kirchoffs law, View factors, Radiation between surfaces- different shapes, Radiation involving gases and vapours, Radiation shields.	09
		Heat Transfer Equipment: Double pipe heat exchangers, Shell and tube heat exchangers – Types of shell and tube heat exchangers, Condenser – types of condensers. Design of heat exchanger.	
		Evaporators: Types of evaporators, performance of tubular evaporator – Evaporator capacity, Evaporator economy, Multiple effect evaporator.	
04		Diffusion : Molecular diffusion in fluids, Diffusion coefficient, Flick's Law of diffusion, Dependence of diffusion coefficient on temperature, pressure and composition, Diffusion in multi-component gas mixtures. Diffusion in solids: Molecular, Knudsen &surface diffusion Inter- phase mass transfer, Mass transfer coefficients ,Diffusion between phases , Equilibrium solubility of gases in liquids, Mass Transfer theories, Mass transfer in fluidized beds , flow past solids and boundary layers , Simultaneous heat and mass transfer.	09

05	Mass Transfer in Bioprocess Operations: Role of Diffusion in Bioprocessing, Oxygen Uptake in Cell Culture, Factors affecting cellular oxygen demand, oxygen transfer from gas bubble to cell, oxygen transfer in fermenters, sparging stirring and medium properties, anti foaming agents, temperature, gas pressure and oxygen partial pressure, presence of cells, measuring dissolved oxygen concentration, estimating oxygen solubility, effect of oxygen partial pressure, effect of temperature, effect of solutes, mass transfer correlations, measurement of kLa, oxygen balance method, dynamic method, sulphite oxidation method, oxygen transfer in large vessels.	09
06	Distillation. simple, steam & equilibrium distillation, fractionation. Mccabe-Thiele method, azeotropes. numericals.	08

References:

1. Robert E Treybal, Mass Transfer Operations, McGraw Hill Third Edition
2. Diffusion: Mass Transfer in Fluid System (Cambridge series in Chemical Engineering) by E.L.Cussler"
3. McCabe & Smith, Unit Operations in Chemical Engineering, 6th Edition, McGraw Hall, 2001.
4. Coulson and Richardson, Chemical Engineering Vol I, 4th Edition, Pergmon
5. Press,1998.
6. Badger & Banchero, Introduction to Chemical Engineering, TMH 6th Reprint, 1998.
7. Doran P.M, Bioprocess Engineering Principles, Academic Press
8. Bailey G.E and Ollis D.F, Bioprocess Engineering Fundamentals McGraw Hill
9. Shuler M.L and Kargi F, Bioprocess Engineering- Basic Concepts, Pearson Education
10. Blanch H.W and Clark D.S, Biochemical Engineering Marcel Dekker Inc.

Course Code	Course/Subject Name	Credits
BTL407	**Fermentation Technology Lab**	**2**

List of Experiments Suggested:

1) Alcohol production by baker's yeast

2) Spore counting by haemocytometer

3) Cell immobilization technique by immobilizing yeast cells in calcium alginate beads.

4) Production of citric acid by A.niger

5) Hydrolysis of sucrose by immobilized yeast cells

6) Determination of cell mass by different methods (dry weight method, density method and haemocytometer method)

7) Estimation of carbohydrates from fermentation media.

8) Production of amylase

9) Isolation of auxotrophic mutants of industrially important microorganisms

10) Study of substrate utilization kinetics of the organism

11) Study the set up of various types of bioreactors

12) Introduction to fermentor

Course Code	Course/Subject Name	Credits
BTL408	**Analytical Methods In Biotechnology Lab**	**1.5**

List of Experiments Suggested:

1) Chromatography of amino acids and sugars

2) Agarose gel electrophoresis

3) SDS-PAGE

4) Iso-electric Focussing

5) Centrifugation

6) Density gradient Centrifugation

7) Affinity chromatography

8) Ion exchange chromatography

9) Gel filtration chromatography

10) UV-Visible spectrophotometer

11) Thin Layer Chromatography

12) Paper Chromatography

Course Code	Course/Subject Name	Credits
BTL409	**Unit Operations - II Lab**	**1.5**

List of Experiments Suggested:

- Plate type H.E

- Natural convection

- Forced convection

- Critical Heat flux

- Emissivity

- Heat transfer through composite wall

- Shell & Tube H.E

- k of insulating material

- Simple distillation

- Steam distillation

- Vapor-liquid equilibrium

- Diffusivity of a liquid

- Diffusion through porous solids

- Determination of Mass transfer coefficients in Gas Liquid sysytem by evaporation

- Determination of Mass transfer coefficients in Liquid Liquid system.