SAVITRIBAI PHULE PUNE UNIVERSITY, PANE

M.E./M. Tech. (Biotechnology Engineering)

Structure and Syllabus

(w. e. f. 2015-2016)

M.E./M. Tech. (Biotechnology Engineering) Structure and Syllabus (w. e. f. 2015-2016)

SEMESTER-I

Code	Subject	Teaching scheme	Examination Scheme					Credits
		Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
			In Sem. Assessment	End Sem. Assessment				
515101	Applied Biology	4	50	50	-	-	100	4
515102	Biostatics and Applied Mathematics	4	50	50	-	-	100	4
515103	Fermentation Technology	4	50	50	-	-	100	4
515104	Research methodology	4	50	50	-	-	100	4
515105	Elective I	5	50	50	-	-	100	5
515106	Lab Practice I	4	-	-	50	50	100	4
Total		**25**	**250**	**250**	**50**	**50**	**600**	**25**

SEMESTER-II

Code	Subject	Teaching scheme	Examination Scheme					Credits
		Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
			In Sem. Assessment	End Sem. Assessment				
515107	Bioreaction Engineering	4	50	50	-	-	100	4
515108	Advanced Biotechnology	4	50	50	-	-	100	4
515109	Unit Operations in Biotechnology	4	50	50	-	-	100	4
515110	Elective II	5	50	50	-	-	100	5
515111	Lab Practice II	4	-	-	50	50	100	4
515112	Seminar I	4			50	50	100	4
Total		**25**	**200**	**200**	**100**	**100**	**600**	**25**

SEMESTER-III

Code	Subject	Teaching scheme	Examination Scheme					Credits
		Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
			In Sem. Assessment	End Sem. Assessment				
615101	Management in biotechnology	4	50	50	-	-	100	4
615102	Advanced analytical technology	4	50	50	-	-	100	4
615103	Elective III	5	50	50	-	-	100	5
615104	Seminar II	4	-	-	50	50	100	4
615105	Project stage I	8	-	-	50	50	100	8
Total		**25**	**150**	**150**	**100**	**100**	**500**	**25**

SEMESTER-IV

Code	Subject	Teaching scheme	Examination Scheme				Credits
		Lect./Pr.	Paper	TW	Oral/Presentation	Total	
			-				
615106	Seminar III	5	-	50	50	100	5
615107	Project work stage II	20	-	150	50	200	20
Total		**25**		**200**	**100**	**300**	**25**

List of electives

Elective I	Elective II
1. Advanced Bioseparation 2. Enzyme technology 3. Genetics, genomics and epigenetics 4. Thermodynamics	1. Advanced Bioinformatics 2. Stem cell and Cancer Biology 3. Process modelling and simulation 4. Nanobiotechnology

Elective III
1. Entrepreneurship, IPR and biosafety 2. Nutrition and food processing 3. Advance downstream processing 4. System biology

SEMESTER I

Semester – I
Applied Biology [515101]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515101	4	50	50	-	-	100	4

History and scope of Microbiology. Introduction to microbial diversity.

Prokaryotes, Eukaryotes. Archaebacteria and eubacteria. Structure and function of bacteria. Bacterial spores. Cell division. Reserve food material, Growth, continuous and batch culture, synchronous culture. General features and importance of algae, fungi and protozoa.

Catabolic principles and breakdown of carbohydrates, Glycolysis, lipids, Oxidative and substrate level phosphorylation. Fermentation of carbohydrates. Homo- and heterolactic fermentations. Respiratory metabolism, Embden Mayer Hoff pathway, Entner Doudoroff pathway. Glyoxylate pathway. Kreb's cycle. Reverse TCA cycle. Gluconeogenesis. Pasteur effect. ETCElectron carriers. Artificial electron donors. Inhibitors, Uncouplers

Diversity in microbial metabolism, Aerobic and anaerobic metabolism, Chemolithotrphy, chemoorganotrophy, photolithotrophs, etc. Sulfur, iron, hydrogen , nitrogen oxidations, Methanogenesis, Acetogens, Metabolism and fueling reactions.

Nirogen fixation, Biofertilizers, Microbial polysaccharides, Biopesticides, Antibiotics, Industrial production of lactic acid, citric acid, acetic acid, enzymes viz. Proteases, amylases, cellulases. Steroid conversions and their industrial applications. Biogums, Bioplastics, Biochips, Biosensors. Nanotechnology.

DNA Structure: Watson-Crick model, A,B,Z structures, physicochemical properties, DNA supercoiling and packaging in eukaryotes, Euchromatin, heterochromatin, UV absorption, thermal denaturation, Tm, hyperchromicity.

DNA Replication, RNA types, tRNA, mRNA, rRNA structural features, introns and exons, RNA splicing, Transcription, reverse transcriptase, structure of gene, Genetic Code, Protein Biosynthesis, process of translation, post-translational modifications, protein synthesis in prokaryotes and eukaryoutes.

Books:

1. Caldwell, DR 1995. Microbial physiology and metabolism. Brown Pub.

2. Stanier RY, Ingraham JL and Wheelis, ML and Painter PR 1986. General CBS Pub (AVI Pub. Comp.)
3. Freifelder D. Molecular Biology, Jones and Barrtlett Publishers 1987

Reference Books:

1. Moat AG & Foster JW 1999. Microbial Physiology.
2. Wiley Microbiology. Mac Millan Education Ltd., London
3. Brun Y V, and Shimkets LJ 2000. Prokaryotic development. ASM Press.
4. BIOTOL. Biotechnological innovations in chemical synthesis
5. Butterworth-Heinemann. Reed G (ED). Industrial Microbiology.
6. Hershnergev CL, Queener SW and Hegeman Q. 1998. Genetics and biotechnology of industrial
7. microorganisms. American Soc. Microbiology
8. Demain A.L. Biology of industrial microorganisms.
9. Ewesis et al. 1998. Bioremediation principles. McGraw Hill.
10. Harvey Lodish et al 'Molecular Cell Biology' 1999
11. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular
12. Biology of the Cell, 4th edition, Garland Publishing, New York, London, 2002
13. Sambrook and Russell. Molecular Cloning-A Laboratory Manual Vol 1, 2, 3. Third Edition, Cold Spring
14. Harbor Laboratory Press, Cold Spring Harbor, New York 2001
15. T.A. Brown, 'Genomes' John Wiley and Sons PTE Ltd.
16. Ansumbel F.M, Brent R, Kingston R.E, Moore D.D., 'Current protocols in Molecular Biology' Green
17. Publishing Associates, NY 1988
18. Berger S.L., Kimmer A.R, 'Methods in Enzymology' vol 152, Academic Press. 1987
19. I Edward Alcamo, HAR court Academic Press'DNA Technology'

Semester – I
Biostatistics and Applied mathematics [515102]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515102	4	50	50	-	-	100	4

Models in chemical engineering, matrices, operations and transformations, eigen values and eigen vectors, Fredholm alternative, Rayleigh quotient and its application to chemical engineering systems, self adjoint and non-self adjoint systems, partial differential equations and their applications in chemical engineering, Separation of variables and Fourier transformations
Linear and Polynomial Regression: Method of Least Squares: Fitting of a straight line using linear regression, fitting of a parabola using polynomial regression, fitting of other curves.

Interpolation, Finite differences and Interpolation: Forward differences, backward differences, central differences, Factorial notation. Newton's Interpolation formulae with equal intervals: Newton's forward and Newton's backward formulae. Interpolation with unequal intervals: Lagrange's formula, divided differences

Numerical Integration: Newton Cote's quadratic formulae; Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule, Weddle's rule Solutions of Algebraic equations: Bisection method, Regular false method Solutions of linear simultaneous equations: Newton Raphson method, deductions from NR method. Solutions of Non linear simultaneous equations: Newton Raphson method for non linear equations.

Biostatistics: Introduction to Biostatistics Sampling: Introduction, theoretical basis of sampling, Sample method, Essentials of Sampling, random and systematic sampling, cluster sampling, Sample size- determination of sample size, sampling errors. Diagrammatic and graphic presentation, Types of averages, Calculation of Arithmetic mean, Median, Mode, Geometric mean, Harmonic mean for discrete series, Probability and its study, continuous series, individual observations, Standard deviation, and Mean deviation. Tests of Significance: Students t - distribution (parametric), Chi square test (non parametric),

Books:

1. Numerical methods for Engineers with software and programming applications, Steven C Chapra, Reynolds P Canale.
2.Numerical methods for scientific and engineering computation, 5th edition, M.K.Jain, R.K.Jain, S.R.K.Iyengar, New Age International Publishers.
3. Higher Engineering mathematics, Dr. B.S.Grewal, Khanna Publishers.
4. Statistical methods, S.P.Gupta ,Sultan chand and Sons Educational Publishers, New Delhi.

Semester – I
Fermentation Technology [515103]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515103	4	50	50	-	-	100	4

The isolation, preservation and improvement of industrial microorganisms: The isolation of industrially important microorganisms, Isolation methods not utilizing selection of the desired characteristic, The preservation of industrially important microorganisms, The selection of induced mutants synthesizing improved levels of enzymes of industrial, Significance. The use of recombination systems for the improvement of industrial microorganisms, the economics and scale of microbial product fermentations. Different products need different fermentation processes. Fed-batch culture as the paradigm for many efficient microbial processes

Fermentation kinetics & optimization of Process: Introduction Framework for kinetic models Mass balances for bioreactors. Kinetic models Population models- Microbial fermentation as a chemical process. The utilization of fermentation inputs Growth and biomass profiles .The accumulation of fermentation outputs process improvement

Bioreactor Design Considerations: Types of Bioreactors, Single use Bioreactor, Materials of Construction, utilities, risk and containment, vessel design- Basic design aspect ratio, Vessel configuration, Aerator and Agitator- The Agitator – Stirrer glands & bearings, The Stuffing Box, The mechanical Seal, Magnetic Drives, Baffles The aeration system- Porous sparger, orifice sparger, Nozzle sparger, Combined sparger-agitator, Testing new fermenters, nonconventional fermenter designs

Control of Fermentations: An Industrial Perspective Introduction Basic components of on-line process monitoring and control Enzymes- Transducers, Applications reported in the literature, Requirement for control Sensors Controller - Design of a fermentation control system, Fermenter control specification, Control of Incubation Advanced Incubation Control, Other advanced fermentation control options

Bioprocess scale up: Concerns and criteria: Introduction, Scale up concerns of microbial, mammalian and plant cell processes, Scale up criteria, Selection of scale up criteria, Scale up of genetically engineered cell culture fermentation

Books:

1. El-Mansi E.M.T. and Bryce C.F.A. ‘Fermentation Microbiology and Biotechnology’
2. Stanbury P.F. and Whitaker A. ‘Principles of Fermentation Technology’

Reference books:

1. Enzymes: Trevor, Horwood, 2001
2. Young, M.Y. (Eds), Comprehensive Biotechnology Vol. 1- 4: Pergamon Press.
3. T.D. Brock, Smaeur Associates. Biotechnology: A Text Book of Industrial Microbiology, 1990.

Semester – I
Research methodology [515104]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515104	4	50	50	-	-	100	4

Fundamental of Research Definition and meaning of research, importance of research, characteristics of research, steps in research, types of research. Identification of research Problem or Hypothesis. Objectives and sources of problem statement, characteristics of good research problems, Literature Survey What is literature survey, function of literature survey, maintain a note book, developing a bibliography, online tools- Google, cite seer, ACM Digital library, survey papers. Experimental design- Meaning, Needs and features of a good research design. Types of Research Design Reproducibility, sensitivity, validation of equipment and calibration of instrumentData Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection – Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation

Research Report, Types of research report, styles of reporting, steps in drafting research report, editing the final draft. Oral and poster presentation of a scientific data, writing a research paper- Identification of journal, Impact factor, Guidelines to author, abstract, Introduction, result and discussion .Development of a research proposal: Various funding agencies for biotechnology research, formats of proposals by DBT, ICMR, DST, ISRO and DRDO etc. Code of research ethics: ethics - Ethical issues - ethical committees – Commercialization, Reproduction of published material – Plagiarism - Citation and acknowledgement - Reproducibility and accountability.

Books :

1. C.R. Kothari, Research Methodology Methods and Techniques, 2/e, Vishwa Prakashan, 2006
2. Donald H.McBurney, Research Methods, 5th Edition, Thomson Learning, ISBN:81-315-0047-0,2006

Reference Books :

1. Donald R. Cooper, Pamela S. Schindler, Business Research Methods, 8/e, Tata McGraw-Hill Co. Ltd., 2006.
2. Fuzzy Logic with Engg Applications, Timothy J.Ross, Wiley Publications, 2nd Ed[d]
3. Simulated Annealing: Theory and Applications (Mathematics and Its Applications, by P.J. van Laarhoven & E.H. Aarts[e]
4. Genetic Algorithms in Search, Optimization, and Machine Learning by David E. Goldberg

Semester – I
Elective I [515105]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515105	5	50	50	-	-	100	5

Elective I. Advanced Bioseparation

Role of bioseparations in Biotechnology and chemical industries: Bio-molecules of commercial importance – Organic acids and alcohols, antibiotics, vaccines, steroids, vitamins, enzymes, proteins, antibodies etc, major contaminants, requirement of purification, Pitfalls and challenges in bio-separation processes, Product quality requirements, Regulatory aspects and validation, Economics of separation processes, membrane based separation techniques: Membrane based separations-micro and ultra filtration theory, resistance in series model, other models for membrane separations, membrane modules, pervaporation, dialysis, design and configuration of membrane separation equipment, Molecular properties and selection of separation conditions, Equilibrium calculations

Product purification / Enrichment Extraction-Solvent selection and equipment design in extraction processes, aqueous two phase extraction, supercritical extraction, Precipitation - using salts, organic solvents, and polymers, crystallization of small and large biomolecules, product Resolution / Fractionation Adsorptive separation- Definition; Types of adsorption; adsorbents types, their preparation and properties; Types of adsorption isotherms and their importance Chromatographic Separations-Mechanism and modes of chromatographic separation, Reverse Phase, Hydrophobic interaction, Size exclusion, Affinity, Ion exchange, Gel Filtration, Equilibrium theory and column design, Process configurations (packed bed, expanded bed, simulated moving beds), Electrophoretic Separations-Various electrophoresis techniques, capillary electrophoresis, Hybrid separation technologies- Membrane chromatography, electro chromatography etc, polishing of bioproducts

Process integration-combining many bioseparation techniques, computed aided design, design and scale up of process-from biomass to product, emerging trends like pseudo-affinity chromatography, metal ion affinity chromatography, inclusion bodies-processing and refolding, case studies :Protein purification-sources of proteins (microbes, plants and animal sources using classical and modern biotechnology), Conventional strategies, associated problems, new trends, large scale separation and purification of E. coli, yeast and mammalian proteins

Books:

1. J.E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, McGraw-Hill
2. P.A. Belter, E.L. Cussler and W.S. Hu, Bioseparations, John Wiley and Sons Inc.
3. Aenjo J.A. and J.Hong, Separation, Recovery and Purification in Biotechnology
4. P F Stanbury and A Whitaker, Priniciples of fermentation technology, Pergamon press (1984)
5. M. Moo-Young , Comprehensive Biotechnology" Vol.2 (1985)
6. Biotreatment, Downstream Processing and Modeling" (Advances in Biochemical Engineering /Biotechnology, Vol 56) by T. Schepler et al, Springer Verlag
7. C.A. Costa and J.S. Cabral, Kluwer, Chromatographic and Membrane Processes in Biotechnology Academic Publisher
8. J.P. Hamel, J.B. Hunter and S.K. Sikdar,Downstream Processing, American Chemical SoCBEty
9. M.R. Ladisch, R.C. Wilson, C.C. Painton and S.E. Builder, Protein Purification, American Chemical soCBEty ,Verlag

Elective I. Enzyme technology

Historical aspect of enzyme, Nomenclature and classification of enzyme, Enzyme cofactors - prosthetic groups, coenzymes, co-substrates, Role of Metal ions in enzyme catalyzed reaction, structure of enzymes - the monomeric and oligomeric enzymes. Concept of Active Site , Lock and Key and Induced Fit hypotheses. Multienzyme systems - basic concepts and significance with examples, structural aspects of pyruvate dehydrogenase and fatty acid synthetase. Isoenzymes - basic concepts with examples and their significance to the cells and to the medical field.

Basic concept of enzyme catalysis - activation energy barrier and the transition state theory, Catalytic mechanisms in Chemistry and in Enzymes - acid-base, covalent and electrochemical reactions. Factors enhancing the catalytic efficiency of enzymes proximity and orientation, orbital steering, distortion and strain. Functional groups involved in the catalytic mechanisms – example of chymotrypsin, Isolation and purification of enzyme, criteria's of purity of enzyme, Enzyme turnover: Kinetics of enzyme turnover. Measurement of enzyme turnover, Ks and Kd. Correlation between the rates of enzyme turnover and structure and function of enzymes, significance of enzyme turnover.

Kinetics of Enzyme activity : Introduction of Chemical kinetics, Kinetics of Single substrate enzymes catalysed reactions - Michaelis and Menten derivations, Significance of Michaelis and Menten equation and Km. Modifications of the - Michaelis and Menten equation - Lineweaver - Burk, Eadie-Hofstee, Hanes and Eisenthal & Cornish - Bowden. Effect of pH and temperature on enzyme activity.

Regulation of enzyme activity by various means with one example of each, catalytic mechanism of allosteric enzymes, Enzyme inhibition and its kinetics: feedback inhibition, irreversible and reversible inhibition (competitive, non competitive, un competitive), allosteric inhibition. Importance of inhibition studies.

Enzymes in clinical Diagnosis: LDH isozymes, SGOT, SGPT, creatine kinase, alpha amylase, phosphatase.

Immobilization of enzymes: - Introduction, Methods of immobilization, kinetics of immobilized

enzymes & application in production of L-amino acids.Other uses of immobilized enzyme .

Industrial enzymes: like glucose-isomerase, cellulases,pectinases etc., their importance, source and production

Enzyme based biosensors:Introduction to biosensors, Classification of biosensors based on various transducers, different biocomponents employed for the construction of biosensor of the sensor, Selected examples and further development of biosensors

Books:

1. Lubert stryer Biochemistry, Freeman WH & Company, New York
2. Yang V.C. and T.T.Ngo.2000.Biosensors and their Applications, Academic/Plenum Publishers
3. Conn and Stumph, Outlines of Biochemistry JH Weil, General Biochemistry, New Ages International (P) Ltd. 1997.
4. David T. Plummer, An Introduction to practical biochemistry, Tata McGraw Publishing Company Ltd
5. I.A.L. Lehninger, DL Netson, MM Cox Principles of Biochemistry, CBS Publishers and Distributors
6. Ashok Mulchandani and Kim R Rogers, Enzyme and Microbial bio sensors: Techniques and Protocols,(Eds.);Humana Press Totowa ,NJ,1998
7. A.P.F. Turner, G.S. Wilsons Biosensors: Fundamentals and Applications, Oxford Science Publications, Oxford.

Elective I. Genetics, genomics and epigenetics

Basic Concepts in Genetics : Science of genetics, Animal models (Drosophila, Caenorhabditis) in the study of Genetics, Mendelian principles, Concept of Dominance, multiple allelic systems, sex-linked inheritance, Epistasis, Pleiotropy, Penetrance, Mutation, Chromosomal aberrations. Linkage studies, genetic maps, Population genetics: Hardy-Weinberg law, Quantitative genetics and applications, Plant genetics: Inbreeding and heterosis, and plant improvement

Genomics: Introduction to Genomics and Proteomics, sequencing strategies for whole genome analysis, sequence data analysis, Comparative Genomics: Protein evolution from exon shuffling, Protein structural genomics, Gene function by sequence comparison Global expression profiling : whole genome analysis of mRNA and protein expression, microarray analysis, types of microarrays and their applications, Functional genomics, Toxicogenomics, Pharmacogenomics,

Epigenetics: Introduction to histones, chromatin packing, transcription factors and gene expression, Epigenetic mechanisms -chromatin organization, histone modification, DNA methylation, epigenetic regulators, non-coding RNAs, role of epigenetics in biological phenomena such as imprinting, X-inactivation, cellular identity, cellular reprogramming, tumorigenesis, Cancer Epigenetics, neuroepigenetics, Aging, Epigenetic therapies, HDAC inhibition

Books:

1. Campbell, A. Malcolm and Heyer, Laurie J., Discovering Genomics, Proteomics & Bioinformatics, Benjamin Cummings, 2002.
2. Lesk, Arthur M, **Introduction to Protein Science**, Oxford University Press, 2004, ISBN 0 19 926511 http://www.oup.com/uk/orc/bin/9780199265114/resources/figures/
3. S.Sahai, Genomics and Proteomics, " Functional an Computational Aspects ",Pienum Publications, 1999
4. Benjamin Lewin: Gene VII, Oxford University Press, Oxford, New York, 2000
5. Harvey Lodish et al 'Molecular Cell Biology' 1999

Reference books:

1. Fersht, A. Structure and Mechanism in Protein Science, W. H. Freeman (1999).
2. Carey P. R. (Ed.) Protein engineering and design, Academic Press (1996).
3. Strachan T. and Read A. P. Human Molecular Genetics, 2nd edition. Bios (1999)
4. Glick, Bernard R. and Pasternak J. J., Molecular Biotechnology: principles and applications of recombinant DNA, 2nd ed. ASM Press (1998)
5. Brown T. A. Genomes, Bios (1999)
6. Attwood T. K. and Parry-Smith D. J. Introduction to Bioinformatics, Longman (1999)
7. Rees A R., Sternberg M. J. E. and Westsel R., Protein Engineering - a practical approach, IRL Press (1992).

Walker J. M. and Rapley R., Molecular Biology and Biotechnology, 4th ed. Royal Society of Chemistry (2000).

9. Bruce Alberts, Alexander Johnson, Julian Lewis,Martin Raff, Keith Roberts, Peter WalterMolecularBiology of the Cell, 4th edition, Garland Publishing,New York, London 2002

10 **Nature, Genome gateway**:http://www.nature.com/nature/supplements/collections/humangenome/index.html

11 **Science, Human Genome special issue**http://www.sciencemag.org/content/vol291/issue5507/index.dtl

Elective I. Thermodynamics

Classical Thermodynamics:Homogeneous Closed Systems, Homogeneous Open Systems, Energy and first Law; Reversibility and second Law; Review of Basic Postulates, equilibrium criteria, Legendre Transformation and Maxwell's relations, Stability of thermodynamic systems, first order phase transitions and critical phenomenon, phase rule, single component phase diagrams, thermodynamic properties from volumetric and thermal data Equilibrium in a Heterogeneous Closed System, The Gibbus-Duhem Equation, The Phase Rule, The Chemical Potential, Fugacity and Activity, A Simple Application: Raoult□s Law.

Biological Thermodynamics: Energy Definition, Laws of thermodynamics of Universe, Thermodynamics of small systems(molecular motors), Formation of first biological macromolecules- Bacteria, Second law of evolution.

Statistical Thermodynamics: Introduction, Diffussion, Boltzman distribution, Partition function, Analysis of thermodynamic data, Multistate equilibria, Protein Heat capacity function, Cooperative transitions, Interaction free energy, Helix coil transition theory

Applications to Typical Cases : Gibb's free energy – applications- Photosynthesis, Glycolysis,, Citric acid cycles, Oxidative phosphorylation and ATP Hydrolysis, Substrate cycling, Osmosis, Dialysis, Donnan Equilibria, Membrane transport, Enzyme substrate interaction, Molecular pharmacolofgy, Hemoglobin,ELISA, PCR, DNA.

Books:

1. Donald. T.Haynie, "Biological Thermodynamics", Cmbridge University Press 2001.
2. Smith, Van Ness and Abbott, Introduction to Chemical Engineering Thermodynamics, McGraw-Hill (2001)
3. Sandler S.I, "Chemical, Biochemical and EngineeringThermodynamics", 4th Edition, Wiley Student Edition, 2006.

Reference books:

1. Rao., Y.V.C., Chemical Engineering Thermodynamics, University Press, Hyderabad, 2005
2. Tester, J. W. and M. Modell, Thermodynamics and Its Applications. 3rd Edn. Prentice Hall, New Jersey, 1997.

Semester – I
Lab practice I [515106]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515106	4	-	-	50	50	100	4

(Any 8 Practicals)

1. Isolation and characterization of Microorganisms
2. To study growth curve of microorganisms.
3. To estimate protein, DNA from microorganisms at various stages of growth
4. Medium Optimization techniques Plackett Burman, Response surface methodology.
5. Batch, Fed batch and continuous fermentation processes
6. To study effect of various factors (pH, Temperature, agitation etc.) on
   a) Biomass production
   b) Product formation
   c) Substrate utilization
7. To study efficiency of fermentation process
   a) Sugar estimation by DNS method
8. Isolation of DNA RNA, checking purity, quantitation
9. To study molecular methods such as PCR- RFLP
10. Plasmid cloning, ligation, transformation, screening of recombinants
11. Data analysis using Excel, Graph pad or SSPS
12. Study of biostatistics tools

SEMESTER-II

Semester – II

Bioreaction Engineering [515107]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515107	4	50	50	-	-	100	4

Reaction Kinetics: Law of mass action, Rate equation, Elementary, Non-elementary Reactions and their mechanisms. Theories of Reaction Rate and temperature dependency. Analysis of experimental Reactor data; Evaluation of Rate Equation; Integral and differential analysis for constant and variable volume system, Fitting of data to complex reaction mechanisms.

Microbial growth kinetics, substrate utilization and inhibition kinetics, product formation kinetics Principles of biochemical reactions and kinetics; Thermodynamics of bioreactions and biotransformation, Mass Transfer in heterogeneous biochemical reaction systems: determination of oxygen transfer coefficients (kLa); role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems.

Choice of Reactors: Factors affecting choice, optimum yield and conversion, selectivity and reactivity, optimization-output and yield problems, consecutive parallel, and mixed reactions; recycle reactors. Biochemical Engineering kinetics, kinetic Models, Growth, Biochemical Engineering kinetics, kinetic Models, Growth, Product Formation Models, Structured & Unstructured.

Modeling and design of Stirred Tank Bioreactors, Membrane Bioreactors, Immobilized Bioreactors, airlift bioreactor, Flocculation Bioreactors and Fluidized Bed Bioreactor, solid state fermentation systems including mass transfer considerations, Bioreactor operation and control, photobioreactor design parameters and operating conditions, mechanically agitated and sparged reactors, hydrodynamics, heat transfer, mass transfer and scale up aspects of reactors.

Books:

1. Karl Schugerl, Bioreaction Engineering Vol-I , John Wiley & Sons
2. Juan A Asenjo and Jose Merchuk, Bioreactor System Design, Marcel Dekker Inc
3. Joaquim M S Cabral, Manuel M Mota, J Tramper (2001)Multiphase Bioreactor Design, CRC
4. Michael C Flickinger, Stephen W Drew (1999) Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation, Wiley Biotechnology Encyclopedia, Vol I–V, Wiley Interscience Publication, John Wiley & Sons Inc
5. James E. Bailey and David F. Ollis, “Biochemical Engineering Fundamentals”, 2nd Edn., McGraw Hill International Edition, New York, 1986
6. Schuler & Kargi, Bio-process Eng. PHI Chemical Reaction Engineering: Levenspiel O

7. Chemical Engineering Kinetics: Smith J.
8. Elements of Chemical Reaction Engineering: H.Scott, Fogler
9. Aiba S. and Nancy F. Millis, “Biochemical Engineering”, 2nd Edn., Academic Press, New York,1973
10. Pauling M. Doran, Bioprocess engineering principles
11. Web F.C, “Biochemical Engineering”, Van Nostrand, London, 1964

Semester – II

Advanced biotechnology [515108]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515108	4	50	50	-	-	100	4

Recombinant DNA Technology-Tools and techniques used in recombinant DNA technology. Vectors – Prokaryotic and eukaryotic vectors, types, applications, advantages and disadvantages. Expression vectors – pET vectors, Cloning, screening of recombinants, applications in biotech industry. PCR - Principle, types – Quantitative PCR, Inverse PCR, RT PCR, Hotstart PCR,

Human Genome Project, Sequencing, NGS, SNPs, Mutations, Applications in diagnostics, Genetic Disorders: Thalasemia, Sickle cell anemia, GCPD, CH, Adrenal Hyperplacia, Cystic Fibrosis. Types of microarrays, methodology, labeling and hybridization, applications of DNA chips, detection of SNPs, disease diagnostic chips, functional genomics, pharmacogenomics,,

Biosensor & diagnostics Monoclonal Antiboides, Hybridoma Technology, enzymes in clinical diagnostics-principle, applications in industries and disease, Molecular Diagnostics

Biotherapeutics Monoclonal antibodies, Hybridoma technology, rDNA products, Stem cells, Tissue engineering, GMP

Metabolic engineering , Metabolomics, Synthetic Biology, Applications of metabolic engineering

Books:

1. Brown T. A. Gene Cloning and DNA Analysis: An Introduction, Wiley Blackwell Publishers.2001.
2. Old. R.W and Primrose, S. B. 5th Edn. Principles of Gene manipulation: An introduction to Genetic engineering, 3rd edition, Black well Scientific Publications.1994.
3. Lewin B. Genes VIII, Oxford University Press, New York. 2003.
4. Glick, B.R & Pasternak J.J .Molecular Biotechnology, Principles and Applications of Recombinant DNA, American Society for Microbiology, Washington D.C. 2003.
5. Watson .J. D, Baker. T. A, Bell. S. P, Gann. A. N, Levine. M and Losick. R. Molecular biology of the gene, 5th edition, Cold Spring Harbor Laboratory Press. 2003.

6.Tran Minh Canh Biosensors, Chapman and Hall 1993

7. A.P.F. Turner, G.S. Wilsons Biosensors: Fundamentals and Applications, Oxford Science Publications, Oxford

8. Elmer, G. W., Farland, L. V. and Surawicz, C. M., “Biotherapeutic Agents and Infectious Diseases”, Humana Press Inc., Totowa, NJ, USA, 1999

9. Grewal, I. S., “Emerging Protein Biotherapeutics”

Semester – II

Unit operations in Biotechnology [515109]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515109	4	50	50	-	-	100	4

Dimensional Analysis:Units and Dimensions, dimensional homogeneity and dimensionless numbers and similitude.
Fluid Mechanics**:**Definition and classification, types of fluids, types of flow. Equations for flow, Continuity equation, Bernoulli equation, Hagen-Pouseuille equation. Flow over particles and through stagnant fluids, settling and sedimentation.
Fluid flow: Fluid flow measuring devices, pumps, energy calculations and characteristic of pumps.
Mechanical Operations:Size reduction, sieve analysis. Fluid mixing and power consumption in mixing. Fluid solid interactions, sedimentation, filtration and design of filtration equipment.
Heat Transfer:Heat conduction, conduction through single and multi-layers walls, insulations. Convective heat transfer, forced and natural convection, condensation. Design of heat exchangers. Sterilization operations.
Mass transfer: Basics, modes of mass transfer, Fick's law of Diffusion, mass transfer correlations.
Mass transfer operations**:** Distillation, extraction and drying.

Books:

1. Treybal R.E., Mass Transfer Operations –McGraw Hill
2. McCabe W.L. and Smith J.C., Unit Operations of Chemical Engineering, McGraw Hill

Reference books:

1. Coulson J.M. and |Richardson J.F., Chemical Engineering, Vol I & II –McGraw Hill
2. Foust A.S., Principles of Unit Operations in Chemical Engineering,
   Smith B.D., Design of Equilibrium Stage Processes

Semester – II
Elective II [515110]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515110	5	50	50	-	-	100	5

Elective II. Advanced Bioinformatics

Bioinformatics basics: Computers in biology and medicine; Importance of Unix and Linux systems and its basic commands; Database concepts; database query language; Protein and nucleic acid databases; Structural databases; Pattern matching algorithm basics; Databases and search tools: Biological back ground for sequence analysis; Identification of protein sequence from DNA sequence; DNA sequencing; nucleotide databases; Searching of databases similar sequence; The NCBI; Resources at EBI; Database mining tools; Similarity matrices; Sequence alignment- methods, evaluation, scoring; Pairwise alignment; Multiple sequence alignment; Statistical significance of alignment; Sequence similarity search with FASTA3; CLUSTAL W and CLUSTAL X for multiple sequence alignment; SEQUIN; Introduction to Protein Modeling; Force field methods; Energy, Buried and exposed residues; Side chains and neighbors; Fixed regions; Hydrogen bonds; Mapping properties onto surfaces; Fitting monomers; rms fit of conformers; Software accessibility; Building peptides; Protein displays; Substructure manipulations, Annealing.; Protein Structure Prediction: Protein folding and model generation; Secondary structure prediction; Analyzing secondary structures; Protein loop searching; Loop generating methods; Loop analysis; Homology modeling: potential applications, description, methodology, homologous sequence identification; Align structures, align model sequence; Construction of variable and conserved regions; Threading techniques; Topology fingerprint approach for prediction; Evaluation of alternate models; Structure prediction on a mystery sequence; Structure aided sequence techniques of structure prediction; Structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction.

Books:

1. David W. Mount, Bioinformatics: Sequence and Genome Analysis 2nd Edition, CSHL Press, 2004.
2. A. Baxevanis and F. B. F. Ouellette, Bioinformatics: a practical guide to the analysis of genes and proteins, 2nd
3. Edition, John Wiley, 2001.
4. Jonathan Pevsner, Bioinformatics and Functional Genomics,1st Edition, Wiley-Liss, 2003.
5. P. E. Bourne and H. Weissig, Structural Bioinformatics,2nd Edition, Wiley, 2008.
6. C. Branden and J. Tooze, Introduction to Protein Structure, 2nd Revised Edition Garland Publishing, 1998.

Elective II. Stem cell and Cancer Biology

Introduction to stem cell biology and regenerative medicine; Definitions: stem cell, progenitor cells, precursor cells, transit amplifying cells; General properties of stem cells; Defining Totipotency, pluripotency, multipotency, unipotency of stem cells; Differentiation and trans-differentiation. Stem cell niche, growth and differentiation factors. Stem cell lineage tracing: adult and embryonic stem cells, pluripotent stem cells, germ line, neuronal stem cells, hematopoietic stem cells, pancreatic stem cells, cancer stem cells. Isolation and culture of various stem cell types

Stem cell research:Techniques. Lineage – tracing technique, gene knock-out and knock-in studies, inducible gene expression or repression, transfection, DNA sequencing, Chromatin Immunoprecipitation, Fluorescent-Activated Cell Sorting (FACS), Immunolabeling and Magnetic separation (AUTOMACS Miltenyi Biotech, Dynal Biotech Dynal technology), confocal microscopy.

Stem cell research:legal and ethical issues; Guidelines for stem cells research and therapy in India: introduction, general mechanisms, aim and scope, categorization of research on stem cells, clinical application of umbilical cord blood stem cells, criteria on use of placental / fetal stem cells for research, approval of procurement. Human embryonic stem cell Bank: preservation and distribution of cells. International collaboration and patent issues, Ethics for stem cell research

Stem cells and Degenerative diseases: Introduction to Parkinson disease, diabetes, burn, retinal replacement therapy, cardiomyopathies; derangement patterns, clinical manifestations: symptoms and diagnosis; treatment; Application of stem cells in degenerative medicine: Stem cell therapy; Cell replacement and cell regeneration: principles and techniques; Cell and tissue regeneration; Regeneration of different types of stem cells for different degenerative diseases; gene therapy

Cancer Biology: Cell cycle,Cell proliferation, Differentiation and Apoptosis,Initiation, Progression: tumor microenvironment, translational and transcriptional mechanisms Invasion and metastasis; Cancer Genetics: Oncogenes, Tumor suppressor genes; Tumor immunology: dysregulation of signal transduction,

Cancer Therapy: Molecular diagnosis: PCR, FISH, RFLP and Southern Blotting, Microarray technology, Biomarkers, Therapy: Chemotherapeutic agents, endocrine therapy, Biotherapeutics, Stem cell therapy.

Books:

1.RA Weinberg, The Biology of Cancer, John Wiley And Sons Ltd, 2007

2.Raymond W Ruddon, Cancer Biology, 4th Edition, Oxford University Press, 2007

3.S Pelengaris and M Khan, (eds) The Molecular Biology of Cancer, Blackwell Press, 2006

Reference books:

1. Kufe, Pollock, Weischbaum, Bast, Gansler, Holland and Frei, Cancer Medicine Review, 6th edition 2003 (BC Decker)
2. Vogelstein and Kinzler, The Genetic Basis of Human Cancer, 2nd edition 2002 (McGraw-Hill Education)
3. Alberts, Johnson, Lewis, Raff, Roberts and Walter, Molecular Biology of the Cell, 4th edition 2002 (Garland Science)
4. Lodish, Berk, Zipursky, Matsudaira, Baltimore and Darnell, Molecular Cell Biology, 4th edition (WH Freeman)
5. Souhami, Tannock, Hohenberger and Horiot, Oxford Textbook of Oncology, 2nd edition 2001 (Oxford University Press)
6. Lewin B, Genes, 8th Edition 2004 (Pearson, Prentice, Hall)
7. Eeles, Easton, Ponder and Eng (eds.), Genetic Predisposition to Cancer, 2nd edition 2004 (Chapman and Hall)
8. “Insight: Stem Cell Biology”. Nature. 2006; 441:1059-1102.
9. “Insight: Regenerative Medicine”. Nature. 2008; 453:301-352.
10. Roger JB King and Mike W Robbins, Cancer Biology. 3rd Edition, Pearson Education Ltd, 2006
11. Tannock and Hill, The Basic Science of Oncology, 4th edition 2004 (McGraw- Hill Education)

Elective II. Process Modeling and Simulation

Introduction to Simulation through Modeling, Mathematical Models of Chemical Engineering Systems, Uses of mathematical models, Principles of formulations, Material and Energy Balance, Constituent Relationships, Degree of freedom analysis, Types of simulation problems: Design, Rating, Flow sheeting etc. Usefulness and Limitation of Process Simulation. Steady State Lumped System, Mathematical Models of Chemical Engg. Systems: Series of isothermal, constant holdup CSTRs CSTRs with variable holdups. Isothermal/non-isothermal plug-flow reactor. Two heated tanks. Gas phase pressurized CSTR Non isothermal CSTR 7. Single component vaporizer Multi component flash drum Batch reactor Reactor with Mass Transfer Ideal binary distillation column Multi component non-ideal distillation column. Batch distillation with holdup PH systems Lumped parameter model of a gas absorber Lumped parameter model of a liquid-liquid extraction column Model for Heat-exchangers Model for interacting & non-interacting tanks. Model for Biochemical reactor.

Books:

1. Process Dynamics: Modeling, Analysis and Simulation, B Wayne Bequette, Prentice Hall International Inc.
2. Computational Methods for Process Simulation, 2nded., W F Remirez, Butterworth Heinemann.
3. Edgar, T.F. and Himmelblau, D.M.; “Optimization of Chemical Processes”, McGraw-Hill Book Co.
4. Davis M.E., " Numerical Methods and modelling for Chemical Engineers" , Wiley, New York, 1984.

Reference Books:

1. Process Modelling, Simulation and Control for Chemical Engineers by William L. Luyben, McGraw Hill International Editions.
2. Analysis, Synthesis and Design of Chemical Processes, R Turton, R C Bailie, W B Whiting and J A Shaeiwitz, Prentice Hall International Inc..
3. Product and Process Desing PrinciplesSynthesis, Analysis, and Evaluation, 2nded., W D Seider, J D Seader and D R Lewin, John Wiley and Sons Inc
4. Ramirez, W. “Computational Methods in Process Simulation”, Butterworths Publishers

Elective II. Nanobiotechnology
Credits: 5

Introduction to nanomaterials, Properties of materials & nanomaterials, role of size in nanomaterials, nanoparticles, semiconducting nanoparticles, nanowires, nanoclusters, quantum wells, conductivity and enhanced catalytic activity compared to the same materials in the macroscopic state. Synthesis of nano materials-Physical, chemical and Biological methods Characterization of Nanostructures-Structural CharacterizationX-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM). Spectroscopic characterizations:Basic concepts of spectroscopy, operational principle and application for analysis of nanomaterials, UV-VIS-IR Spectrophotometers, Principle of operation and application for band gap measurement, Raman spectroscopy

Applications of nanobiotechnology in early medical diagnostics, drug targeting, drug delivery, nanosurgery and other biomedical field.
Nanodevices & Nanosensors- Functionalization of Sensing Substrates, Biochip, Sensor for bio-medical applications: Cardiology, Neurology and as diagnostic tool, generation of biosensors, immobilization, characteristics, applications, Polymer based sensor, DNA
Biosensors, optical sensors. Biochips.
Nanosensors-Miniaturization of Biosensors, Nanomaterial Based Biosensors. Electron Transfer of Biomolecules, Nanoparticle-Biomaterial Hybrid Systems for Sensing and Electronic Devices, MEMS, Fuel Cells, Effect of Biosensor in biological and physicochemical techniques. Ethical Considerations. Respect for life, Potential dangers

Books:

1. Niemeyer and Mirkin ed. Nanobiotechnology: concepts, applications & perspectives,
2. Jain, KK. Nanobiotechnology in molecular diagnostics: current techniques and Applications
3. Springer Handbook of Nanotechnology - Bharat Bhusan
4. Nanostructures and Nanomaterials - Synthesis, Properties and Applications - Cao, Guozhong.

Reference books:

1. A.Nabok, Organic and Inorganic Nanostructures, Artech House 2005
2. C. Dupas, P. Houdy, M. Lahmani, Nanoscience: Nanotechnologies and Nanophysics, Springer-Verlag Berlin Heidelberg 2007
3. Jeremy Ramsden, Essentials of Nanotechnology, ISBN 978-87-7681-418-2

4. Carl C. Koch, Nanostructured Materials, Second Edition: Processing, Properties and Applications William Andrew Publishing Norwick, NY, USA, 2006. ISBN 10:0-8155-1534-0(0-1855)
5. Hari Singh Nalwa, “Nanostructured Materials and Nanotechnology”, Academic Press, 2002
6. G.L.Hornyak, J.Dutta, H.F.Tibbals, A.K.Rao, Introduction to Nanoscience, CRC Press, 2008, ISBN: 978-1-4200-4805-6
7. **Ozin**, Geoffrey A., **Arsenault**, André C., **Cademartiri**, Ludovico, Nanochemistry, Springer, 2nd ed., 2009, ISBN 978-1-84755-895-4
8. Elements of X –ray Diffraction, B. D. Cullity
9. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton

Semester II
Lab Practice: II [515111]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
515111	4	-	-	50	50	100	4

(Any 8 Practicals)

1. To study production of any two biomolecules (polysaccharides, Bio pesticides, Antibiotics, Lactic acid, citric acid, acetic acid, enzymes etc.)
2. Study of solid state fermentation
3. Study of various factors on biomass formation
4. Study of various factors on substrate utilization
5. Oxygen transfer studies in fermenters
6. RTD and Performance Studies of Bio Reactors
7. Kinetics –study for conversion of glucose to ethanol
8. Analytical methods- Spectroscopic methods for estimations, TLC, GC, HPLC
9. Separation of proteins- SDS PAGE, column chromatography
10. Purification of proteins or enzymes, specific activity determination
11. Immunodiagnostic methods such as ELISA, RID, Western Blot etc.
12. Animal tissue culture- passaging of adherent cell lines, cryopreservation of cells, MTT

SEMESTER-III

Semester III
Management in Biotechnology [615101]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
615101	4	50	50	-	-	100	4

Introduction, Meaning , Concept and Features of Management, Scope and functional areas of management, Roles of management, Levels of management, Management Science: Management, functions, authority and responsibility,concepts of administration and management of organization, Decision making in management by objectives, Business Organization, Personnel Management**,** Purchase and stores management, Concepts of quotation, tenders and comparative statement, inspection and quality control, Inventory, carrying cost and fixed cost of inventory, examples of cost of Inventory, Stores management, functions of storekeeper, methods of inventory : LIFO, FIFO, Marketing management, Export and import management, Quality Management, Management Laws, Void contract, concept of guarantee and warranty, Introduction of MRTP and FERA, Organizing and Staffing, Decentralization of authority and responsibility, Entrepreneur: Meaning Functions and types of Entrepreneur, Role of entrepreneurs in Economic Development:Entrepreneurship in India, Identification of Business Opportunities, Small Scale Industry: Meaning, Nature of Support; Objectives, Definition, Characteristics, Advantages of SSI, Steps to start in SSI – Government policy towards SSI, Functions. Case studies (05)

Books:

1. Tripathi, P.C. and Reddy, P. N., “Principles of Management”, Tata McGraw Hill, 3rd Edition
2. Vasant Desai, “Dynamics of Entrepreneurial Development & Management”,Himalaya Publishing House
3. Poornima M Charantimath, “Entrepreneurship Development – Small Business Enterprises”, Pearson Education, 2006, 2nd Edition
4. Luthans, F., “Organizational Behaviour”, Tenth Edition, Tata McGraw Hill Publications
5. Ramaswamy, V. S. and Namakumari, S., “Marketing Management”, MacMillan India Ltd
6. Kulkarni, P. V. and Satyaprasad, B. G., “Financial Management”, Thirteenth Edition, Himalaya Publishers Ltd.
7. Ebert, R. J. and Everett Adam, “Production & Operations Management”, Fifth Edition, Pearson Publication

Semester III
Advanced Analytical techniques [615102]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
615102	4	50	50	-	-	100	4

Theory, Instrumentation, Methods and applications of UV/ Vis spectrophotometer
Theory and Instrumentation of IR and FT-IR its advantages and applications in structural elucidation. NMR, C13 NMR, Origin of spectra, Chemical shifts, Spin-spin coupling,Coupling constant, Instrumentation and applications in structural elucidation. Mass spectra, Instrumentation, Fragmentation pattern and applications for Structural elucidation.
Application of GC-Mass, HPLC-Mass for complex mixtures.Theory, Instrumentation and application for the following:
i) Fluorescence ii) X – Ray crystallography iii) Atomic spectroscopy iv) Ultra centrifugation v) ES vi) Liquid Scintillation spectrometer vii) Auto radio grapy
Separation Techniques; Fundamental principles, instrumentation, Qualitative and Quantitative applications of Gas-liquid Chromatography, HPLC, HPTLC,), Partition Chromatography, Adsorption Chromatography, Ion Exchange Chromatography, Size Exclusion Chromatography and Affinity Chromatography
Principles and application of light, Phase contrast, Scanning and Transmission electron microscopy, Cytometry and Flow cytometry Hyphenated Analytical Technique : Introduction, Principle, and Instrumentation and
Applications of High Performance Liquid chromatography coupled with mass spectrometry (HPLC-MS) and Gas chromatography coupled with mass spectrometry (HPLC-MS)

Books:

1. Skoog, Principles Of Instrumental Analysis, , Saunders college publishing, Philadelphia.
2. Arnold Heyworth Beckett, John Bedford Stenlake, Practical pharmaceutical chemistry Part 2, Athlone Press, London.
3. Silverstein, Spectrometric identification of organic compounds, Basseler Moril, CBS Publishers and distribution, Delhi.
4. Vogel, Quantitative Chemical Analysis, A.I, ELBS Ed.
5. Indian pharmacopoeia [IP] 2010.

6. Florey, Analytical Profiles of Drugs, Vol.1-16.
7. Sinder, Text Book of HPLC.
8. McLafferty, Mass Spectrometry.
9. Rao,C.N., Ultraviolet Visible Spectroscopy for Chemical Application
10. Silverstein, Basseler, Morril, Spectophotometrc Identification of Organic Compounds.
11. Ewing, Instrumental Methods of Chemical Analysis.

Semester III
Elective III [615103]

Code	Teaching scheme	Examination Scheme					Credits
	Lect./Pr.	Paper		TW	Oral/ Presentation	Total	
		In Sem. Assessment	End Sem. Assessment				
615103	5	50	50	-	-	100	5

Elective III. Entrepreneurship, IPR and Biosafety

Entrepreneurship
Definition. Functions and kinds of entrepreneurs. Intrapreneur, Entrepreneurship and economic development, Entrepreneurial competencies and traits, developing competencies. Project identification, selection and financing. Project report- content and significance, Planning Commission's guidelines for formulating project reports-methods of project appraisals.
Introduction to Intellectual Property
Types of Intellectual property (IP): Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology Agreements and Treaties.History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments
Case Studies Basics of patents and concept of prior art Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional,
Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENT Scope(WIPO), IPO, etc.) Patenting procedures
National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting – disclosure/non-disclosure; Financial assistance for patenting - introduction to existing schemes Patent licensing and agreement Patent infringementmeaning, scope, litigation, case studies Biosafety
Introduction; Historical Backround; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartegana Protocol.

Books:

1. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007

2. Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra, Information Solution Pvt. Ltd., 2007

3. S.S.Kanka Entrepreneurship Development, S.Chand and Co, New Delhi 1997

Elective III. Nutrition and food processing

Human nutritional Requirements – Development and Recent Concepts.

Methods of determining human nutrient need, Basic terms and concepts in human nutrition Guidelines, Recommendations & Development of International and National Nutritional Requirements, Translation of nutritional requirements into Dietary Guidelines.

Body Composition

Significance of body composition and changes through the life cycle, Methods for assessing body composition (both classical and recent) and their applications.

Energy

Components of energy requirements: BMR, RMR,thermic effect of feeding, physical activity. Factors affectingenergy requirements, methods of measuring energy expenditure, Estimating energy requirements of individuals and groups, Regulation of energy metabolism and body weight: Control of food intake – role of leptin and other hormones

Nutritional significance of Biomolecules:

Carbohydrates: Review of nutritional significance of carbohydrates and changing trends in dietary intake of different types of carbohydrates and their implications Dietary fibre: Types, sources, role and mechanism of action Resistant starch

Proteins: Overview of role of muscle, liver and g.i. tract inprotein metabolismAmino acid and peptide transportersTherapeutic applications of specific amino acids Peptides of physiological significanceProteins, amino acids and gene expression

Lipids: Nutritional significance of fatty acids – SFA, MUFA, And PUFA: functions and deficiency Role of n-3 and n-6 fatty acids, Prostaglandins, Trans Fatty Acids Conjugated linoleic acid Nutritional Requirements and dietary guidelines (International and National) for visible and invisible fats in diets. Lipids and gene expression

Vitamins (A, D4, D10, E3, E8, K3, K8)

Historical background Structure and chemistry Food sources Metabolism (digestion, absorption, transport, storage and elimination), Bioavailability and factors affecting bioavailability, Biochemical and physiological functions, Assessment of status Interaction with other nutrients, regulation of gene expression (wherever applicable) Pharmacological and therapeutic effects

Introduction to Physical and chemicals methods of food preservation: Principles and methods of food preservation- Refrigeration, Freezing, heating, dehydration, drying, canning, extrusion cooking, hydrostatic pressure cooking, dielectric heating, microwave processing, aseptic processing, juices and concentrates, membrane technology, additives, irradiation. Storage of food, modified atmosphere packaging.

Advanced Food Processing

Role of Enzymes in Food Processing: Starch and sugar conversion processes or baking by amylases; de-oxygenation and desugaring by glucose oxidase; beer mashing and chill-proofing or cheese making by proteases and various other enzyme catalytic actions in food processing. Enzyme in bakery and cereal products, production of pectinases and utilization in food Processing Technologies for Food Ingredients:

Technologies used for microbial production of food ingredients, Biotechnology of microbial polysaccharides in food, Microbial biotechnology of food flavor production, microbial production of oils and fats, food applications of algae, butanol production from agricultural biomass.
Concept of public nutrition
Relationship between health and nutrition. Role of public nutritionists in the health care Delivery Sectors and Public Policies relevant to nutrition and health.Primary Health Care of the Community. National Health Care Delivery System Determinants of Health Status..Indicators of Health Population Dynamics. Demographic transition Population structure Fertility behavior Population policy Fertility inter-relationship between Nutrition and Quality of Life

Books:

1. Kalidas Shetty, Gopinadhan Paliyath, Anthony Pometto, Robert E Levin, Food Biotechnology (Second Edition)–Taylor and Francis
2. Frazier, Food Microbiology,
3. Fellows P. , Ellis H., 1990 – Food Processing Technology Principles and Practice –New York

Reference books:

1. Shils, M.E.; Olson, J.; Shike, M. and Roos, C. (1998): Modern Nutrition in Health and Disease. 9th edition. Williams and Williams. A Beverly Co. London.
2. Bodwell, C.E. and Erdman, J.W. (1988) Nutrient Interactions. Marcel Dekker Inc. New York
3. Berdanier, C.D. and Haargrove, J.L. (ed) (1996): Nutrients and Gene Expression: Clinical Aspects. Boca Raton, FL CRC Press.
4. Baeurle, P.A. (ed) (1994) Inducible Gene Expression. Part I: Environmental
5. T.P.Coultate – Food – The Chemistry of its components, 2nd edition Royal Society, London,1992.
6. B. Shivshanker – Food Processing and Preservation, Prentice Hall of India Pvt. Ltd. New Delhi 2002.

Elective III. Advanced Downstream processing

Role of Downstream Processing in Biotechnology

Bio-molecules of commercial importance – Organic acids and alcohols, antibiotics, vaccines, steroids, vitamins, enzymes, proteins, antibodies etc, major contaminants, requirement of purification, Pitfalls and challenges in bio-separation processes, Product quality requirements, Regulatory aspects and validation, Economics of downstream processing

Membrane based separation techniques

Membrane based separations-micro and ultra filtration theory, resistance in series model, other models for membrane separations, membrane modules, pervaporation, dialysis, design and configuration of membrane separation equipment, Molecular properties and selection of separation conditions, Equilibrium calculations

Product purification / Enrichment

Extraction-Solvent selection and equipment design in extraction processes, aqueous two phase extraction, supercritical extraction, Precipitation - using salts, organic solvents, and polymers, crystallization of small and large biomolecules

Product Resolution / Fractionation

Adsorptive separation- Definition; Types of adsorption; adsorbents types, their preparation and properties; Types of adsorption isotherms and their importance

Chromatographic Separations-Mechanism and modes of chromatographic separation, Reverse Phase, Hydrophobic interaction, Size exclusion, Affinity, Ion exchange, Gel Filtration, Equilibrium theory and column design, Process configurations (packed bed, expanded bed, simulated moving beds)

Electrophoretic Separations-Various electrophoresis techniques, capillary electrophoresis

Hybrid separation technologies- Membrane chromatography, electro chromatography etc, polishing of bioproducts

Downstream processing: overall strategy

Process integration-combining many bioseparation techniques, computed aided design, design and scale up of process-from biomass to product, emerging trends like pseudo-affinity chromatography, metal ion affinity chromatography, inclusion bodies-processing and refolding

Case studies

Protein purification-sources of proteins (microbes, plants and animal sources using classical and modern biotechnology), Conventional strategies, associated problems, new trends, large scale separation and purification of *E. coli*, yeast and mammalian proteins

Other examples: Baker's yeast, Ethanol, Power alcohol, Citric acid, Gluconic acid, Penicillin, Streptomycin, Insulin, Casein, interferon, Recombinant products

Books:

1. J.E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, McGraw-Hill
2. P.A. Belter, E.L. Cussler and W.S. Hu, Bioseparations, John Wiley and Sons Inc.
3. Aenjo J.A. and J.Hong, Separation, Recovery and Purification in Biotechnology

Reference books:

1. P F Stanbury and A Whitaker, Priniciples of fermentation technology, Pergamon press (1984)
2. M. Moo-Young , Comprehensive Biotechnology" Vol.2 (1985)
3. Biotreatment, Downstream Processing and Modeling" (Advances in Biochemical Engineering /Biotechnology, Vol 56) by T. Schepler et al, Springer Verlag
4. C.A. Costa and J.S. Cabral, Kluwer, Chromatographic and Membrane Processes in Biotechnology Academic Publisher
5. J.P. Hamel, J.B. Hunter and S.K. Sikdar,Downstream Processing, American Chemical Society
6. M.R. Ladisch, R.C. Wilson, C.C. Painton and S.E. Builder, Protein Purification, American Chemical society ,Verlag

Elective III. Systems biology

Systems Biology – Fundamentals Overview of Gene Control –Working of Genetic Switches – Introductory Systems Biology The biochemical paradigm, genetic paradigm and the systems paradigm

Equilibrium Binding and Co-operativity -Michaelis- Menten Kinetics –identical and independent binding sites – Identical and interacting binding sites, non- interacting binding sites.

Genetic switch in Lambda Phage -Noise-based Switches and Amplifiers for Gene Expression.

Synthetic genetic switches –Ecoli chemotaxis – biological oscillators- genetic oscillators -The Origin and Consequences of Noise in Biochemical Systems

Developmental Systems Biology-Building an Organism Starting From a Single Cell -Quorum Sensing – Programmed Population Control by Cell-Cell Communication and Regulated Killing-Drosophila Development.Establishment of Developmental Precision and Proportions in the Early Drosophila embryo

Gene expression networks-Gene regulation at a single cell level- Transcription Networks -basic concepts -coherent Feed Forward Loop (FFL) and delay gate -The incoherent FFL - Temporal order, Signaling networks and neuron circuits -Aspects of multi-stability in gene networks

Reference Books:

Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, (Chapman & Hall/CRC Press Mathematical and Computational Biology), 2nd edition, 2006

Lab Practice I & II:

The laboratory work will be based on completion of assignments confined to the courses of that semester.

SEMINAR:

The student shall deliver the seminar on a topic approved by authorities.

Seminar I : Shall be on state of the art topic of student's own choice approved by an authority. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute.

Seminar II : shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

Seminar III: shall preferably an extension of **seminar II.** The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

PROJECT WORK

The project work shall be based on the knowledge acquired by the student during the coursework and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems based on area where the student likes to acquire specialized skills.

Project Stage – I and II [615105 & 615107]

Code	Teaching scheme	Examination Scheme				Credits
	Lect./Pr.	Paper	TW	Oral/Presentation	Total	
615106	5		50	50	100	5
615107	20		150	50	200	20

Assessment of Project stage-I has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

INSTRUCTIONS FOR DISSERTATION WRITING

It is important that the procedures listed below be carefully followed by all the students of M.Tech. (Biotechnology Engineering).

1. Prepare **Three Hard Bound Copies** of your manuscript.

2. Limit your Dissertation report to 80 – 120 pages (preferably)

3. The footer must include the following:

Institute Name, M.Tech. Biotechnology (Biotechnology Engineering) Times New Roman 10 pt. and centrally aligned.

4. Page number as second line of footer, Times New Roman 10 Pt, centrally aligned.

5. Print the manuscript using

   a. Letter quality computer printing.
   b. The main part of manuscript should be Times New Roman 12 pt. with alignment - justified**.**
   c. Use 1.5 line spacing.
   d. Entire report shall be of 5- 7 chapters

6. Use the paper size **8.5'' × 11''** or **A4 (210 × 197 mm).**
   Please follow the margins given below.

Margin Location	Paper 8.5'' × 11''	Paper A4 (210 × 197 mm)
Top	1''	25.4 mm
Left	1.5''	37 mm
Bottom	1.25''	32 mm
Right	1''	25.4 mm

7. All paragraphs will be 1.5 line spaced with a one blank line between each paragraph. Each Paragraph will begin with without any indentation.

8. Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.

9. Sub-Section headings should be aligning at the left with 12 pt, bold and Title Case (the first letter of each word is to be capitalized).

10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, **black and white. Illustrations downloaded from internet are not acceptable.**

    a. Illustrations should not be more than **two** per page. One could be ideal
    b. Figure No. and Title at bottom with **12 pt**
    c. Legends below the title in **10 pt**
    d. Leave proper margin in all sides
    e. Illustrations as far as possible should not be photo copied.

11. **Photographs** if any should of glossy prints

12. Please use **SI** system of units only.

13. Please **number the pages** on the front side, centrally below the footer

14. **References** should be either in order as they appear in the thesis or in alphabetical order by last name of first author

15. **Symbols** and **notations** if any should be included in nomenclature section only

16. Following will be the order of report
    i. **Cover page** and **Front page** as per the specimen on separate sheet
    ii. **Certificate** from the Institute as per the specimen on separate sheet
    iii. **Acknowledgements**
    iv. **List of Figures**
    v. **List of Tables**
    vi. **Nomenclature**
    vii. **Contents**
    viii. **Abstract** (A brief abstract of the report not more than **150 words**. The heading of abstract i.e. word "Abstract" should be **bold, Times New Roman, 12 pt** and should be typed at the **centre.** The contents of abstract should be typed on new line without space between heading and contents. Try to include one or two sentences each on **motive, method, key-results** and **conclusions** in Abstract

1 Introduction (2-3 pages) (TNR – 14 Bold)

1.1 Problem statement (TNR – 12)
1.2 Objectives
1.3 Scope
1.4 Methodology
1.5 Organization of Dissertation

2 Literature Review (20-30 pages)
Discuss the work done so far by researchers in the domain area and their significant conclusions. No Derivations, figures, tables, graphs are expected.

3 This chapter shall be based on your own simulation work (Analytical/ Numerical/FEM/CFD) (15-20 pages)

4 Experimental Validation - This chapter shall be based on your own experimental work (15-20 pages)

5 Concluding Remarks and Scope for the Future Work (2-3 pages)

References ANNEXURE (if any) (Put all mathematical derivations, Simulation program as Annexure)

17. All section headings and subheadings should be numbered. For sections use numbers **1, 2, 3, ….** and for subheadings **1.1**, **1.2**, **….** etc and section subheadings **2.1.1**, **2.1.2, ….** etc.

18. **References** should be given in the body of the text and well spread. No verbatim copy or Excessive text from only one or two references. If **figures** and **tables** are taken from any reference then indicate source of it. Please follow the following procedure for references

Reference Books

Collier, G. J. and Thome, J. R., Convective boiling and condensation, 3rd ed., Oxford University Press, UK, 1996, pp. 110 – 112.

Papers from Journal or Transactions

Jung, D. S. and Radermacher, R., Transport properties and surface tension of pure and mixed refrigerants, *ASHRAE Trans*, 1991, 97 (1), pp. 90 – 98. Bansal, P. K., Rupasinghe, A. S. and Jain, A. S., An empirical correction for sizing capillary tubes, *Int. Journal of Refrigeration*, 1996, 19 (8), pp.497 – 505.

Papers from Conference Proceedings Colbourne, D. and Ritter, T. J., *Quantitative assessment of flammable refrigerants in room air conditioners*, Proc. of the Sixteenth International Compressor Engineering Conference and Ninth International Refrigeration and Air Conditioning Conference, Purdue University, West Lafayette, Indiana, USA, 2002, pp. 34 – 40.

Reports, Handbooks etc.

United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps, Technical Option Committee, 2002, Assessment - 2002. ASHRAE Handbook: Refrigeration, 1994 (Chapter 44)

Patent Patent no, Country (in parenthesis), date of application, title, year.

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