B. Tech. in Biotechnology

Yr.	THIRD SEMESTER						FOURTH SEMESTER					
	Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
II	MAT 2153	Engineering Mathematics – III	2	1	0	3	MAT 2254	Engineering Mathematics – IV	2	1	0	3
	BIO 2151	Biochemistry	3	1	0	4	BIO 2251	Chemical and Biochemical Engineering Thermodynamics	3	1	0	4
	BIO 2152	Bioprocess calculations	3	1	0	4	BIO 2252	Downstream processes	3	1	0	4
	BIO 2153	Cell Biology	2	1		3	BIO 2253	Molecular Biology & Genetic Engineering	3	1	0	4
	BIO 2154	Fluid flow operations	3	1	0	4	BIO 2254	Principles of Heat and Mass transfer operations	3	1	0	4
	BIO 2155	Microbiology	2	1	0	3	*** ****	Open Elective – I				3
	BIO 2161	Biochemistry lab	0	0	6	2	BIO 2261	Molecular Biology and Genetic Engineering Lab	0	0	3	1
	BIO 2162	Microbiology lab	0	0	3	1	BIO 2262	Unit Operations Lab	0	0	3	1
			15	**6**	**9**	**24**			**14**	**5**	**6**	**24**
		Total Contact Hours (L + T + P)	**30**					**Total Contact Hours (L + T + P) + OE**	**25 + 3 = 28**			
	FIFTH SEMESTER						SIXTH SEMESTER					
III	HUM 3051	Engg Economics and Financial Management	2	1	0	3	HUM 3052	Essentials of Management	2	1	0	3
	BIO 3151	Bioinformatics	3	1	0	4	BIO 3251	Animal Plant Biotechnology and Bioethics	3	1	0	4
	BIO 3152	Bioprocess Engineering	2	1	0	3	BIO 3252	Bioprocess control and instrumentation	2	1	0	3
	BIO 3153	Bioreaction Engineering	3	1	0	4	BIO 3253	Program Elective - I	2	1	0	3
	BIO 3154	Separation processes	3	1	0	4	BIO 3254	Program Elective - II	2	1	0	3
	*** ****	Open Elective – II				3	*** ****	Open Elective – III				3
	BIO 3161	Bioinformatics lab	0	0	6	2	BIO 3261	Animal, Plant Biotechnology and Bioprocess Engineering lab	0	0	6	2
	BIO 3162	Downstream and separation processes lab	0	0	3	1	BIO 3262	Bioreaction Engineering and Bioprocess control Lab	0	0	6	2
			13	**5**	**9**	**24**			**11**	**5**	**12**	**23**
		Total Contact Hours (L + T + P) + OE	**27 + 3 = 30**					**Total Contact Hours (L + T + P) + OE**	**28 + 3 = 31**			
IV	SEVENTH SEMESTER						EIGHTH SEMESTER					
	BIO ****	Program Elective - III	2	1	0	3	BIO 4298	Industrial Training				1
	BIO ****	Program Elective - IV	2	1	0	3	BIO 4299	Project Work/ Practice School				12
	BIO ****	Program Elective - V	2	1	0	3						
	BIO ****	Program Elective - VI	2	1	0	3						
	BIO ****	Program Elective - VII	2	1	0	3						
	*** ****	Open Elective – IV				3						
			10	**5**	**0**	**18**						**13**
		Total Contact Hours (L + T + P) + OE	**15 + 3 = 18**									

Minor Specialization		Other Electives
I. Environmental Biotechnology BIO 4051: Bioremediation BIO 4052: Design of Biological Treatment Processes BIO 4053: Microbial Treatment of Wastewater BIO 4054: Solid Waste Management **II. Pharmaceutical Biotechnology** BIO 4055: Biomaterials BIO 4056: Biopharmaceutical Engineering BIO 4057: Immunotechnology BIO 4058: Molecular Modeling & Drug Design **III. Material Science** PHY ****: PHY ****: PHY ****: PHY ****: **IV. Business Management** HUM 4051: Financial Management HUM 4052: Human Resource Management HUM 4053: Marketing Management HUM 4054: Operation Management	**V. Computational Mathematics** MAT 4051: Applied Statistics and Time Series Analysis MAT 4052: Computational Linear Algebra MAT 4053: Computational Probability and Design of Experiments MAT 4054: Graphs and Matrices	BIO 4059: Advanced Bioprocess Engineering BIO 4060: Biofuels Engineering BIO 4061: Bioprocess Equipment Design BIO 4062: Biosensors BIO 4063: Biostatics and Design of Experiments BIO 4064: Computational Biology BIO 4065: Food process Engineering and Technology BIO 4066: Genomics and Proteomics BIO 4067: Health Diagnostics BIO 4068: Metabolic Engineering BIO 4069: Bioprocess Modelling and Simulation in Biotechnology BIO 4070: Protein Engineering BIO 4071: Solid State Fermentation **Open Electives** BIO 4301: Biological Databases and Biological Data Mining BIO 4302: Introduction to Biofuels & Biopolymers BIO 4303: Introduction to Bioinformatics

THIRD SEMESTER

MAT 2153: ENGINEERING MATHEMATICS III [2 1 0 3]

Periodic Functions, odd and even functions, Euler's formulae. Half range expansions, Harmonic analysis. Fourier integrals & transforms, Parseval's identity. Functions of complex variable. Analytic function, C-R equations, differentiation, Integration of complex function, Cauchy's integral formula. Taylor's and Laurent Series, Singular points, Residues, Cauchy's residue theorem. Conformal mappings, bilinear transformations. Gradient, divergence and curl, their physical meaning and vector identities. Line, surface and volume integrals. Green's theorem, divergence and Stokes' theorem, applications. Formation, solutions of equations involving derivatives with respect to one variable only. Solutions by indicated transformations and separation of Variables. Derivation of one dimensional wave equation (vibrating string) and its solution by using the method of separation of Variables. D'Alembert's solution of wave equation. Derivation of one dimensional heat equation using Gauss divergence theorem and solution of one dimensional heat equation. Solution by separation of variables.

References:

1. Erwin Kreyszig. *Advanced Engineering Mathematics,* (7e), Wiley & Sons Inc.,1993
2. Murray R. Spiegel. *Vector Analysis,* (2e), Schaum Publishing Co., 2009
3. B.S. Grewal. *Higher Engg. Mathematics,* (43e), Khanna Publishers, 2014
4. Ramana B.V. *Engineering Mathematics,* (2e), Tata McGraw Hill, 2007

BIO 2151: BIOCHEMISTRY [3 1 0 4]

Introduction to biochemistry and human biology, Classification of organisms according to their source of energy, Biochemical evolution, Urey-Miller experiment, Molecular organization in the cell, Organic molecules used by living systems, Molecular evolution in vitro – Sol Spiegelman's experiment, RNA as catalysts, The Genetic code, Amino acids, Proteins, Protein structure (primary to higher level). Enzymes: role, specificity and regulation, Carbohydrates, Classification, Bioenergetics, Burning food, Conserving energy for biological needs, by using coupled reactions, Lipids, Classification and metabolism, Metabolism of Nucleic acids, ATP as an energy currency, Citric acid cycle and oxidative phosphorylation, Metabolic pathways, catabolic and anabolic. Glycolysis, Flow of carbon, nitrogen and energy through interconnected pathways.

References:

1. Lehninger, A. L., Nelson, D. L. 1., & Cox, M. M. *Lehninger principles of biochemistry* (5e). New York ; New Delhi: W.H. Freeman; 2008.

2. Jeremy M Berg, John L Tymoczko, and Lubert Stryer. *Biochemistry*, (5e). New York: W H Freeman; 2002.
3. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (Eds) *Molecular Biology of the cell* (5e), Garland Science, 2008.

BIO 2152: BIOPROCESS CALCULATIONS [3 1 0 4]

Bioprocess Development: An Interdisciplinary Challenge , Biotechnology and Bioprocess Engineering, Biologist and Engineers differ in their approach to research, Introduction to Engineering Calculations, Physical Variables, Dimensions and Units, Unit conversion, Pressure, Standard Conditions and Ideal Gases, Presentation and Analysis of Data, plotting graphs using excel, Stoichiometry of microbial growth and product formation, Steady state material balances, Law of Conservation of Mass, Material Balances With Recycle, By-Pass and Purge Streams, Basic Energy Concepts, Intensive and Extensive Properties, General Energy-Balance Equations, Procedure For Energy-Balance Calculations Without Reaction, Energy-Balance Equation For Cell Culture, Unsteady-State Material-Balance Equations, Unsteady-State Energy-Balance Equation

References:

1. Pauline Doran. *Bioprocess Engineering Principles*. Academic Press, 1995
2. David M. Himmelblau. *Basic Principles and Calculations in Chemical Engineering*. Prentice Hall of India (P) Ltd, 2012

BIO 2153: CELL BIOLOGY [2 1 0 3]

Introduction to cell chemistry and biosynthesis, Visualizing cells, Sexual reproduction: Meiosis, The cell cycle, Germ Cells and Fertilization, Development of Multicellular Organism, Specialized Tissues, Stem Cells, and Tissue Renewal, Membrane structure, Transport of small molecules and the electrical properties of membranes, Intracellular compartments and protein sorting, Intracellular vesicular traffic, The cytoskeleton, Apoptosis, Cell junctions, Cell Adhesion, and the Extracellular Matrix, Mechanisms of cell communication, Uncontrolled cell division- Cancer.

References:

1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (Eds) *Molecular Biology of the cell* (5e), Garland Science, 2008.
2. Harvey Lodish, Arnold Berk , Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C .Martin .*Molecular cell biology*, (8e). Scientific American Books, W. H. Freeman, New York, 2016

BIO 2154: FLUID FLOW OPERATIONS [3 1 0 4]

Review of fluid statics, fluid dynamics. Basic equations of fluid flow – continuity equation, Bernoulli's equation. Reynolds number and friction factor, Hagen Poiseuille equation. Flow past immersed bodies – boundary layer. Flow through a bed of solids – Ergun, Kozeny Carmen and Blake Plumer equation. Agitation and mixing of liquids. Transportation and metering of fluid. Dimensional analysis and similitude

References:

1. McCabe & Smith. *Unit Operations of Chemical Engineering*. McGraw Hill, 1993
2. Coulson and Richardson. *Chemical Engineering, Vol. I*. ELBS, 2001

BIO 2155: MICROBIOLOGY [2 1 0 3]

Introduction to Prokaryotes and Eukaryotes. Microbiological Techniques – Study of microscopes, Various sterilization techniques. Functions and Replication of Bacteria, Viruses, Fungi, Algae, Protozoans. Common diseases caused by microbes. Microbial insecticides, Microbial enzymes, Microbial polysaccharides. Microbial spoilage of food, food preservatives and food borne infections. Biofertilizers – Nitrogen fixing organisms.

References:

1. Pelczar, Chan and Kreig. *Microbiology*. W C Brown Pub, 1998
2. Presscot and Dunn. *Industrial Microbiology*. CBS Publishers, 2004

BIO 2161: BIOCHEMISTRY LAB [0 0 6 2]

This laboratory deals with both qualitative and quantitative analysis of biomolecules such as carbohdrates, proteins, lipids and nucleic acids. The estimation of carbohydrates is done qualitatively by Osazone test and the reducing sugars are analysed using Dinitrosalicylic acid (DNS) method. Besides, the estimation of glucose is done by both DNS method as well as by enzymatic (GOD/POD) method. Simple polysaccharides such as starch is estimated by Iodine method. The specific activity of amylase is also done. Proteins are estimated by Lowry's and Bradford's methods. Amino acids are estimated by Sorenson's titrimetric method. Estimation of cholesterol by Zak's method, and spectrophotometric detection of DNA/RNA are also introduced.

References:

1. Albert Lehninger. *Principles of Biochemistry*. CBS Publishers. 1996
2. Voet and Voet. *Biochemistry*. Wiley. 2005

BIO 2162: MICROBIOLOGY LAB [0 0 3 1]

Experiments are based on the preparation of broth and agar media for the growth of bacterial species. Pure culture techniques (streak, pour and spread) are taught to isolate and sub-culture a specimen obtained from natural sources. Experiments are also designed to learn how to stain and view different types of microbes using a compound microscope. A basic set of biochemical tests are also performed to identify and differentiate between certain microbial classes. A biochemical test is also conducted to check the extent of contamination of a milk sample.

References:

1. David Friefelder. *Molecular Biology*. Jones and Bartlett Publishers Inc. 1987
2. Benjamin Lewin. *Genes VII*. Oxford University Press. 2003

FOURTH SEMESTER

MAT 2254: ENGINEERING MATHEMATICS – IV [2 1 0 3]

Formation of Linear Programming problem, Graphical method, Simplex method, Penalty cost and two phase methods. Finite sample spaces, conditional probability and independence, Bayes' theorem. One dimensional random variable, mean, variance, Chebyshev's inequality. Two and higher dimensional random variables, covariance, correlation coefficient, regression, least squares principles of curve fitting. Binomial, Poisson, uniform, normal, gamma, Chi-square and exponential. Finite difference expressions for first and second order derivatives (ordinary and partial).Solution of BVP's in ODE. Classification of second order linear partial differential equations. Numerical solutions of two dimensional Laplace and Poisson equations by standard five point formula. Solution of one dimensional heat and wave equations by explicit methods. Crank-Nicolson method. Finite element method, Introduction, simple applications. Difference equations representing physical systems, the z transforms, properties of z transforms, initial and final value theorems, solution of difference equations by the method of z transforms, convolution theorem.

References:

1. Kreyzig E. *Advanced Engineering Mathematics*, 7th Edition, John Wiley & Sons, Inc., 1993
2. Meyer P.L. *Introduction to probability and Statistical applications,* (2e), American Publishing Co., 1970
3. Hamdy A Taha. *Operation research,* (7e), Pearson Education, Inc., 2002
4. Grewal B.*S. Higher Engineering Mathematics,* (3e), Khanna Publishers, 2014
5. Sastry S.S. *Introductory methods for Numerical Analysis,* (5e), PHI Learning Private Limited., 2012

BIO 2251: CHEMICAL AND BIOCHEMICAL ENGINEERING THERMODYNAMICS

[3 1 0 4]

Introduction – Scope and definition, First law of Thermodynamics, Joule and Joule-Thomson Coefficient. Definition of enthalpy, different thermodynamic processes, Second law of thermodynamics – Statements of second law, Carnot's engine, entropy, entropy change of ideal gas. Thermodynamic properties of fluid – Property relations for homogenous phases, Solution thermodynamics – Fundamental property relation, Chemical potential and Phase Equilibria, Partial molal properties. Ideal gas mixtures, Fugacity, Activity, residual and excess properties. Single component two phase system, two component phase equilibrium. Chemical reaction equilibrium – Reaction Co-ordinate, Standard Gibb's Energy change and Equilibrium constant. Colligative Properties of solutions: freezing point depression, boiling point elevation, Vapor pressure lowering, osmotic pressure. Thermodynamics of Biochemical reactions – Free energy calculations

References:

1. J.M. Smith, H.C. Van Ness and M.M. Abbott. *Introduction to Chemical Engineering Thermodynamics,* McGraw Hill International (7e) 2010
2. Silbey, Alberty, Bawendi. *Physical Chemistry*, Wiley India (4e), 2004
3. Donald T. Haynie. *Biological Thermodynamics,* Cambridge University Press, 2001

BIO 2252: DOWNSTREAM PROCESSES [3 1 0 4]

Role, importance and economics of downstream processing in biotechnological processes; Process design criteria for various classes of bio-products; Different methods of cell disruption– Advantages & Disadvantages; Removal of insoluble, biomass and particulate debris separation; Membrane based separations (Micro-and Ultra-filtration) theory; design and configuration of

membrane separation equipment and applications; Precipitation methods with salts, organic solvents, and polymers; colloidal stability of protein solutions; kinetics of protein aggregation; Liquid – liquid extraction of bioproduct and Aqueous Two Phase Extraction.

References:

1. Sivasankar B. *Bioseperations: Principles and Techniques*, PHI Learning Pvt. Ltd., 2006
2. Belter P.A., Cussler E., Wei Shan Hu. *Bioseparation – Downstream processing for biotechnology*, Wiley Interscience Pub., 1988
3. Asenjo J. *Separation Processes in Biotechnology*, Marcel Dekker, 1993
4. BIOTOL Board. *Product Recovery in Bioprocess Technology*, Butterworth-Heinemann Ltd, 1990

BIO 2253: MOLECULAR BIOLOGY AND GENETIC ENGINEERING [3 1 0 4]

Cell cycle, Proteins associated with cell cycle, Organization and replication of DNA in Prokaryotic and Eukaryotic Chromosomes – Histones, $C_o t$ curves, θ-mode of Replication, Displacement (D) Loops, Rolling Circle Method (σ–mode) of DNA Replication, Telomeric Replication in Eukaryotes, Transcription in Prokaryotes and Eukaryotes, Regulation of Gene Expression, Post-transcriptional Modifications – RNA Splicing, Translation in Prokaryotes and Eukaryotes, Post-translational Modifications, Biochemical mechanisms of DNA Repair, Types of Mutations, Biochemical basis of mutants, Modes of Mutagenesis, Reversion.

Introduction to cloning, Method of creating recombinant DNA, Cloning Vectors, Expression Vectors, Enzymes in Genetic Engineering, Hybridization and DNA Libraries, Restriction Mapping, Design of Adaptors & Linkers, Polymerases chain reaction (PCR): Types and its applications, Restriction Fragment Length Polymorphisms (RFLP), Methods of Nucleic Acid Sequencing, Applications of Recombinant DNA Technology, Genome editing strategies-CRISPR/Cas9.

References:

1. David Friefelder, *Essentials of Molecular Biology*, Jones and Bartlett Publishers Inc 2015
2. Benjamin Lewin, *Genes IX*, Oxford University Press 2006
3. James D.Watson, Amy A. Caudy, Richard M. Myers, *Recombinant DNA: Genes and Genomes – A short course*, W H Freeman & Co 2006
4. James D Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann and Michael Levine, *Molecular Biology of the Gene*, Pearson 2013

BIO 2254: PRINCIPLES OF HEAT AND MASS TRANSFER OPERATIONS [3 1 0 4]

Various modes of heat transfer, Conduction –Fourier's law, Convection – Natural and forced convection, Co-current and countercurrent types of flow, LMTD, overall coefficient determination of film coefficients, Dimensional analysis, Analogies, Heat transfer with phase change, boiling and condensation; Radiation; Diffusion, Fick's law of diffusion, Flux for stagnant and equimolal conditions; Mass transfer coefficient; Theories of mass transfer; two film theory; Dimensionless numbers, analogies between momentum heat and mass transfer, equipments for mass transfer, HETP and stage.

References:

1. Pauline M. Doran. *Bioprocess Engineering Principles,* Academic Press, 1995
2. Robert E. Treybal. *Mass Transfer Operations*, McGraw-Hill, 1980
3. McCabe & Smith. *Unit Operations of Chemical Engineering*. McGraw Hill, 1993

BIO 2261: MOLECULAR BIOLOGY AND GENETIC ENGINEERING LAB [0 0 3 1]

Experiments are based on the extraction and electrophoresis of nucleic acids (plasmid and genomic) from bacterial and plant sources. Restriction digestion and ligation of DNA is also performed to understand the concepts of targeted gene modification. Bacterial cells are made competent and transformed with a gene of interest to calculate the transformation efficiency. An experiment is also based on the polymerase chain reaction for large-scale of amplification of target sequence in a given DNA sample.

References:

1. Sandy B. Primrose, Richard M. Twyman and Robert W. Old. *Principles of Gene Manipulation,* Wiley-Blackwell Publishers, 2002
2. Benjamin Lewin. *Genes VII*. Oxford University Press, 2003

BIO 2262: UNIT OPERATIONS LAB [0 0 3 1]

Unit operations laboratory curriculum comprises of experiments based on fluid flow and heat transfer. Fluid flow experiments are based on flow measurement, flow dynamics in pipes and

fittings and particle dynamics under fluid flow. Heat transfer experiments aim to estimate heat transfer coefficients and thermal conductivity of metals and insulators.

References:

1. Pauline M. Doran. *Bioprocess Engineering Principles,* Academic Press, 1995
2. McCabe & Smith. *Unit Operations of Chemical Engineering*. McGraw Hill, 1993

FIFTH SEMESTER

HUM 3051: ENGINEERING ECONOMICS AND FINANCIAL MANAGEMENT [2 1 0 3]

Nature and significance, Micro & macro differences, Law of demand and supply, Elasticity & equilibrium of demand & supply. Time value of money, Interest factors for discrete compounding, Nominal & effective interest rates, Present and future worth of single, Uniform gradient cash flow. Bases for comparison of alternatives, Present worth amount, Capitalized equivalent amount, Annual equivalent amount, Future worth amount, Capital recovery with return, Rate of return method, Incremental approach for economic analysis of alternatives, Replacement analysis. Break even analysis for single product and multi-product firms, Break even analysis for evaluation of investment alternatives. Physical & functional depreciation, Straight line depreciation, Declining balance method of depreciation, Sum-of-the-years digits method of depreciation, Sinking fund and service output methods, Costing and its types – Job costing and Process costing, Introduction to balance sheet and profit & loss statement. Ratio analysis - Financial ratios such as liquidity ratios, Leverage ratios, Turn over ratios, and profitability ratios.

References:

1. Blank Leland T, Tarquin Anthony J. *Engineering Economy*, McGraw Hill, 2002
2. Chan S. Park. *Contemporary Engineering Economics*, Pearson Education, Inc. 2010
3. Raman B.S. *Advanced accountancy*, United publications, 1993
4. T. Ramachandran. *Accounting and Financial Management*, Scitech Publications Pvt. Ltd., 2001
5. Thuesen G.J & Thuesen H.G. *Engineering Economics*, Prentice Hall of India, 2005

BIO 3151: BIOINFORMATICS [3 1 0 4]

Internet Basics, Central Dogma of Biology. Databases – Sequence Databases, Retrieving Database Entries and Structure databases. Database Sequence Search & Alignment: The evolutionary basis of sequence alignment, FASTA, BLAST, Low Complexity Regions, Progressive Alignment

Methods, Motifs and Patterns, Presentation Methods. Phylogenetic Analysis – Elements of phylogenetic Models, Data Analysis, Phylogenetics on the web. Predictive Methods using Nucleotide sequence – Detecting ORFs, Exons and Introns, DNA Microarray. Predictive Methods using Protein sequences – Physical properties based on sequence, secondary structure and folding classes, specialized structures, tertiary structure. PCR Primer Design – Restriction mapping, design programs and software.

References:

1. Andreas D Baxevanis. *BIOINFORMATICS – A practical Guide to the Analysis of Genes and Proteins*. Wiley Interscience, 2004.
2. David R. Westhead. *Instant Notes: Bioinformatics.* BIOS Scientific Publishers Ltd., 2003

BIO 3152: BIOPROCESS ENGINEERING [2 1 0 3]

Introduction to Enzymes and Enzyme catalyzed reactions: Nature and function of enzymes, Michaelis-Menten Equation – derivations, types of enzyme inhibition, kinetics. Media Design and Sterilization: Fermentation processes, Medium requirements for fermentation processes - examples of simple and complex media. Thermal death kinetics of microorganisms; Batch and continuous heat sterilization. Transport Phenomena in Bioreactors: Immobilization methods; Immobilized enzyme/cell kinetics: effectiveness factor derivations. Oxygen transfer in submerged fermentation processes: OTR, OUR calculations, kLa estimations. Kinetics of Microbial Growth and Product Formation: Microbial cell kinetics, Monod model; Growth associated and non-growth associated product formation kinetics.

References:

1. Michael L Shuler and Fikret Kargi. *Bioprocess Engineering: Basic Concepts*. Prentice-Hall of India Pvt Ltd 2008
2. Pauline M. Doran. *Bioprocess Engineering Principles*. Academic Press, 1995
3. PF Stanbury, S. Hall, A. Whitaker, *Principles of Fermentation Technology*, (2e), Elsevier Science Publishers, 2003

BIO 3153: BIOREACTION ENGINEERING [3 1 0 4]

Reaction Kinetics – Rate equation, elementary, non-elementary reactions. Analysis of experimental batch reactor data by integral and differential analysis. Ideal Reactors – Design of

batch, stirred tank and tubular flow reactors. Multiple reactor system – size comparison, recycle reactor. Bioreactors– Batch reactor and chemostat with Monod cell growth kinetics, Fed-batch reactor. Non-ideal reactors – E, F curves, RTD for ideal reactors, analysis of RTD data, Micro and Macro fluid.

References:

1. Octave Levenspiel. *Chemical Reaction Engineering*. John Wiley & Sons, (3e), 2003
2. Harvey W. Blanch and Douglas S. Clark. *Biochemical Engineering*, CRC Press, 1997
3. John Villadsen. *Bioreaction Engineering Principles*. (3e), springer publishers 2011

BIO 3154: SEPARATION PROCESSES [3 1 0 4]

Review of VLE–Methods of distillation: Fractionation of binary systems- design calculations, McCabe Thiele method; Theory of absorption, temperature effect in absorption, process design of absorption; Theories of adsorption – Adsorption isotherms and calculations, adsorption in fixed beds; Leaching-Principle, equilibria, calculation; Chromatography – principles of chromatographic separation, different types of chromatographic separations, selection of chromatographic matrices and large-scale chromatographic separation processes; Electrophoretic separations; Size exclusion chromatography; Crystallization, theories of crystallization, calculations; Drying-theory and batch drying curve, different types of dryers and their features

References:

1. Sivasankar B. *Bioseperations: Principles and Techniques*, PHI Learning Pvt. Ltd., 2006
2. Belter P.A., Cussler E. and Wei Shan Hu. *Bioseparation – Downstream processing for biotechnology*, Wiley Interscience Pub, 1988
3. Asenjo J. *Separation Processes in Biotechnology*, Marcel Dekker, 1993
4. BIOTOL Board. *Product Recovery in Bioprocess Technology*, Butterworth-Heinemann Ltd, 1990
5. McCabe and Smith. *Unit Operations of Chemical Engineering*, McGraw Hill Inc.,1993
6. Treybal R.E. *Mass transfer operations*, McGraw Hill, 1980

BIO 3161: BIOINFORMATICS LAB [0 0 6 2]

This laboratory introduces a pragmatic approach on sequence retrieval, alignment, and analysis such as similarity search including pairwise and multiple alignment, basics of PERL programming, primer design, molecular phylogeny with various algorithms such as NJ, UPGMA, FM & ME, secondary structure prediction, structure visualization and analysis, structure alignments to explore

homology as well as distant relationship, protein homology-based modeling, and structure validations.

References:

1. Andreas D Baxevanis. *BIOINFORMATICS – A practical Guide to the Analysis of Genes and Proteins*. Wiley Interscience, 2004
2. David R. Westhead. *Instant Notes: Bioinformatics.* BIOS Scientific Publishers Ltd, 2003

BIO 3162: DOWNSTREAM AND SEPARATION PROCESS LAB [0 0 3 1]

Experiments are based on aqueous two phase based separation, extraction of intracellular proteins, precipitation of proteins, ultrafiltration, separation of solids from slurry using leaf filter and sedimentation.

References:

1. Belter P.A., Cussler E. and Wei Shan Hu. *Bioseparation – Downstream processing for biotechnology,* Wiley Interscience Pub, 1988
2. Asenjo J. and Dekker M. *Separation Processes in Biotechnology,* 1993

SIXTH SEMESTER

HUM 3052: ESSENTIALS OF MANAGEMENT [2 1 0 3]

Definition of management and systems approach, Nature & scope, The functions of managers, Corporate social responsibility. Planning: Types of plans, Steps in planning, Process of MBO, How to set objectives, Strategies, Policies & planning premises, Strategic planning process and tools. Nature & purpose of organising, Span of management, factors determining the span, Basic departmentalization, Line & staff concepts, Functional authority, Art of delegation, Decentralisation of authority. HR planning, Recruitment, Development and training. Theories of motivation, Special motivational techniques. Leadership - leadership behaviour & styles, Managerial grid. Basic Control Process, Critical Control Points & Standards, Budgets, Non-budgetary control devices. Profit & loss control, Control through ROI, Direct, Preventive control. Managerial practices in Japan & USA & application of Theory Z. The nature & purpose of international business & multinational corporations, unified global theory of management. Entrepreneurial traits, Creativity, Innovation management, Market analysis, Business plan concepts, Development of financial projections

References:

1. Koontz D. *Essentials of Management,* Mc Graw Hill, New York, 2004
2. Peter Drucker. *Management, Task and Responsibility,* Allied Publishers, 2006
3. Peter Drucker. *The practice of management,* Butterworth Hein Mann, 2003

BIO 3251: ANIMAL, PLANT BIOTECHNOLOGY AND BIOETHICS [3 1 0 4]

Plant cell cultivation – Biochemistry of major metabolic pathways, Autotrophic and heterotrophic growth, Plant growth regulators and elicitors. Cell suspension culture development – methodology, kinetics of growth and product formation, Hairy root cultures and their cultivation. Animal cell metabolism, Animal cell growth characteristics, Principles of sterile techniques, Regulation and nutritional requirements for mass cultivation of animal cell cultures. Animal cell cultivation – Substrate and product transport through mammalian cell, Animal cell growth kinetics and shear force. Micro and Macro carrier attached growth, Cell culture in continuous, perfusion and hollow-fiber reactor. Public acceptance issues for biotechnology – Case studies from developing and developed countries. Biotechnology and hunger – Challenges for the Indian Biotechnological research and industries. The legal and socioeconomic impacts of biotechnology. Intellectual property rights (IPR), Plant breeder's rights – Legal implications

References:

1. Dixon R.A. and Gonzales. *Plant Cell Culture: A Practical Approach,* IRL Press. 1995
2. Lindsey K. and Jones M.G.K. *Plant Biotechnology in Agriculture,* Prentice Hall, 1990
3. Singh K. *Intellectual property rights on biotechnology,* BCIL, New Delhi, 2001

BIO 3252: BIOPROCESS CONTROL AND INSTRUMENTATION [2 1 0 3]

Measurement and signal transmission of process parameters – Flow, Pressure, Temperature, Level, pH, DO, density and viscosity; Mathematical modeling of chemical and bioprocesses; Introduction to Laplace Transforms, Development of Transfer functions. Dynamic behavior of first and second order processes; Introduction to feedback controllers, feedforward and ratio controller, final control elements and controller tuning; Block diagram representation, Stability of closed loop control systems -Routh stability criterion, Root locus diagrams.

References:

1. Seborg D.E., Edgar T.F. and Mellichamp D.A. *Process Dynamics and control*, John Willey & Sons, 2004
2. Stephanopoulos G. *Chemical Process Control: An Introduction to Theory and Practice*. Prentice Hall International, 1983
3. Riggs J.B. and Nazmul Karim M. *Chemical and bioprocess control*. Ferret Publisher, 2008

BIO 3261: ANIMAL, PLANT BIOTECHNOLOGY AND BIOPROCESS ENGINEERING LAB [0 0 6 2]

In the Animal and Plant Biotechnology lab experiments are based culture media preparation and the growth of animal and plant cells. In Bioprocess Engineering lab experiments are based on estimation of enzyme kinetics, optimum temperature, pH and evaluation of the type of inhibition during enzyme catalyzed reactions.

Reference books:

1. Dixon R.A. and Gonzales. Plant Cell Culture: A Practical Approach, IRL Press. 1995
2. Lindsey K. and Jones M.G.K. Plant Biotechnology in Agriculture, Prentice Hall, 1990
3. Michael L Shuler and Fikret Kargi. *Bioprocess Engineering: Basic Concepts*. Prentice-Hall of India Pvt Ltd 2008

BIO 3262: BIOREACTION ENGINEERING AND BIOPROCESS CONTROL LAB [0 0 6 2]

Bioreaction Engineering laboratory experiments are based on the growth kinetics of bacterial species in a shake flask and fed-batch cultures with various carbon sources. Also experiments are designed to evaluate the performance of various bioreactors such as stirred tank reactor (STR) and fluidized bed reactor (FBR) and packed bed reactor (PBR) with immobilized enzymes. In Bioprocess control lab experiments are designed to study about the controllers (P, PI, PD & PID), advanced control system, control valves, first order system & second order system (inherent/multi capacity processes) with different inputs which usually appears in the process industries.

References:

1. Octave Levenspiel. *Chemical Reaction Engineering*. John Wiley & Sons, (3e), 2003
2. Harvey W. Blanch and Douglas S. Clark. *Biochemical Engineering*, CRC Press, 1997
3. John Villadsen. *Bioreaction Engineering Principles*. (3e), springer publishers 2011

SEVENTH SEMESTER

There are five program electives and one open elective with total of 18 credits to be taught in this semester.

EIGHTH SEMESTER

BIO 4298: INDUSTRIAL TRAINING

Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken in a phased manner during the vacation starting from the end of third semester. Student has to submit to the department a training report in the prescribed format and also make a presentation of the same. The report should include the certificates issued by the industry.

BIO 4299: PROJECT WORK/PRACTICE SCHOOL

The project work may be carried out in the institution/industry/ research laboratory or any other competent institutions. The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation of the project work shall be done after about 8 weeks. An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation. The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form. Student has to make a presentation on the work carried out, before the department committee as part of project evaluation.

MINOR SPECIALIZATIONS

I. ENVIRONMENTAL BIOTECHNOLOGY

BIO 4051: BIOREMEDIATION [2 1 0 3]

Introduction, Advantages and Disadvantages of Bioremediation; Factors influencing Bioremediation; Microbial ecology and metabolism; Biodegradation of common contaminant compounds; Bioremediation processes; Biological Filtration Processes for Decontamination of Air Stream; Biotreatment of Metals; Phytoextraction; Rhizofiltration; Phytostabilization; Biomonitoring; Biomembrane Reactors; Successful and Unsuccessful Case Studies in Bioremediation Process

References:

1. Martin Alexander. *Biodegradation and Bioremediation*. Academic press. 1999
2. John. T. Cookson, Jr. *Bioremediation engineering; design and application*. McGraw Hill, Inc. 1995
3. Eweis, Ergas, Chang and Schroeder. *Bioremediation Principles*. McGraw-Hill Series in Water Resources and Environmental Engineering, 1998

BIO 4052: DESIGN OF BIOLOGICAL TREATMENT PROCESSES [2 1 0 3]

Flow and Mass loading for treatment plants; Various Physical units operations-equalization tank design, sedimentation tank design by solid flux and batch data, dissolved air flotation; Filtration mechanism in water treatment and design of filters, Chemical treatment and precipitation; Activated sludge process and different types of active sludge processes; Mathematical model development for active sludge process, and design, Sequencing batch reactors (SBR), Plug flow aerobic treatment, Rotating Biological contactor and model, Trickling filters and roughing filters and various design parameters, Various pond processes, Disinfection-Mechanisms, Mathematical Models for disinfection, Breakpoint chlorination and calculations; Design considerations in anaerobic processes; Water reuse and reclamation technologies, Risk assessment.

References:

1. Metcalf and Eddy. *Wastewater Engineering - Treatment, Disposal and Reuse*. Tata McGraw Hill Publishing Co. Ltd, 1991
2. Rao C.S. *Environmental Pollution Control Engineering.* New Age International (P) Ltd. Publishers, 1991

3. Jordening H.J., and Winter J. *Environmental Biotechnology: Concepts and Applications.* Wiley-VCH Verlag GmbH & Co., 2005

BIO 4053: MICROBIAL TREATMENT OF WASTE WATER [2 1 0 3]

Need for wastewater treatment; Characterization of wastewater- Biological- BOD, COD, TOC, MPN, and Bacterial count; BOD kinetic parameter fitting by Least square, Fujimoto, Daily difference, Thomas and Moments-Methods; Physical characterization such as solids, Turbidity, and Chemical characterizations. Bacterial metabolism in treatment, Decomposition of organic compounds in Ecosystem, Biology, Mass energy balance for Aerobic respiration, and Anaerobic respiration, General considerations for Aerobic Vs. Anaerobic treatment, Kinetic aspects, Hydrolysis of cellulose-biological aspects, Anaerobic degradation of lignocellulose and cellulose, proteins, fats; Various types of anaerobic treatment reactors-UASB and its variations, calculation of biogas by Buswell equation, Nitrification and denitrification processes, and Anammox process, Biological Phosphorus removal processes.

References:

1. Metcalf and Eddy. *Wastewater Engineering - Treatment, Disposal and Reuse*. Tata McGraw Hill Publishing Co. Ltd, 1991
2. Rao C.S. *Environmental Pollution Control Engg*. New Age International (P) Ltd. Publishers, 1991
3. Jordening H.J. and Winter J. *Environmental Biotechnology: Concepts and Applications.* Wiley-VCH Verlag GmbH & Co., 2005

BIO 4054: SOLID WASTE MANAGEMENT [2 1 0 3]

Integrated solid waste management, operation of waste management systems. Legislative Trends and Impacts; Composition of municipal solid wastes, Properties of MSW; transformations of solid waste; Properties, classification and transformation of Hazardous wastes and its management; Collection of solid waste**,** Separation, processing and Transformation of solid waste, Transfer and Transport, Disposal; Landfill methods & its design; Biological principles, aerobic composting, Anaerobic digestion, Biological transformation processes. Energy production from biological conversion products, Fermentation and compost processes: design parameters & Applications; Meeting federal and state mandated diversion goals; Recycling, Implementation of solid waste management options; planning, siting and permitting of waste management facilities.

References:

1. George Tchobanoglous. *Integrated solid waste management: Engineering principles and management issues*, Mcgraw Hill, 1993
2. William D Robinson. *The solid waste handbook: A practical guide*, John Willy & sons, 1986

II. PHARMACUETICAL BIOTECHNOLOGY

BIO 4055: BIOMATERIALS [2 1 0 3]

Properties of materials & classes of materials used in Medicine, Host reaction to biomaterials and their evaluation, testing biomaterials, degradation of materials in the biological environment, application of materials in medicine & dentistry, implants & devices, basics of artificial organs.

References:

1. Buddy Ratner, Allan Hoffman, Frederick Schoen, Jack Lemon. *Biomaterial Science: An introduction to materials in medicine*, Academic press, Elsevier publication, (3e), 2012
2. Joon Park, Lakes R.S. *Biomaterials: An Introduction*, Springer publication, (3e), 2007

BIO 4056: BIOPHARMACEUTICAL ENGINEERING [2 1 0 3]

Introduction – Development of drugs and pharmaceutical industry organic therapeutic agents. Drug Metabolism and Pharmaco-Kinetics – physico chemical principles, radioactivity, action of drug on human bodies. Important Unit Processes and Their Applications. Manufacturing Principles of different type of tablets. Analytical methods and test for various drugs and pharmaceuticals, packaging techniques – quality control. Health Biotechnology – health care products, edible vaccines, nutrition value of foods. Health bioinformatics – microbes and human health, biotechnology kits to monitor day to day human health.

References:

1. Heinrich Klefenz. *Industrial pharmaceutical biotechnology*, Wiley-VCH, 2002
2. Susanna Wu-Pong, Yongyut Rojanasakul, and Joseph Robinson. *Biopharmaceutical drug and design and development.* Humana Press, 1999

BIO 4057: IMMUNOTECHNOLOGY [2 1 0 3]

Immune system – innate and adaptive immunity, Lymphocytes - origin and differentiation. Humoral Immunity – B-lymphocytes and their activation, structure and function of immunoglobulins, Genetic control of antibody production. Cellular Immunology – T cells classification, APC, mechanisms of phagocytosis. Antigen Antibody interactions – precipitation, agglutination, neutralization. Immunological and antibody based assays. Stem cells – applications to immunology, immunosuppressive drugs. Autoimmunity – Auto antibodies in humans, treatment of auto immune disorders. Molecular Immunology – Preparation of vaccines, application of rDNA technology to production of antibodies.

References:

1. Roitt I. *Essential Immunology.* Blackwell Scientific Publications, 1991
2. Richard Goldsby, Thomas J. Kindt, Barbara A. Osborn. *Kuby Immunology*. W H Freeman, 2006

BIO 4058: MOLECULAR MODELING AND DRUG DESIGN [2 1 0 3]

General concepts of Pharmacology – Bioavailability, Compartments and clearance, Drug absorption and transport, Drug metabolism, Pharmacokinetic models, BBB. Drug Structure – Chemoinformatics & Chemical Graphs. Drug Design – Computational Drug Discovery, Binding interactions, Lipinski's rule of five (RO5), SMILES, Molecular Descriptors – chemical, topological and geometrical descriptors. Molecular Modeling – Molecular Orbital theory, 1D, 2D and 3D analyses. Computer Simulation Methods – Molecular Dynamics methods, Binding affinity calculations & conformational analysis, QSAR. Design New Molecules – *De novo* ligand design, Similarity search - Virtual screening, Molecular docking – SNPs and Pharmacogenomics, Toxicology, Clinical trials, Regulatory affairs & Patenting.

References:

1. Leach A.R. *Molecular Modelling Principles and Applications.* Longman, 2001
2. Haile J.M. *Molecular Dynamics Simulation Elementary Methods.* J. Wiley and Sons, 1997

OTHER ELECTIVES

BIO 4059: ADVANCED BIOPROCESS ENGINEERING [2 1 0 3]

Environmental requirements for Animal Cell Cultivation-Oxygen requirement, Formulation of optimum culture media, techniques for increasing cellular productivity. Bioreactor systems for animal cell cultivation-, Air-lift fermenter, bubble column bioreactor, Fixed bed bioreactor with micro carriers, Scale-up strategy for animal cell cultivation. Classification of interactions between two species- Neutralism; Mutualism; Commensalism; Amensalism and competition. The Lotka-Volterra Model of Predator-Prey Oscillations. Design of fermentation processes-steady state operation of CSTR with microbial cultures, Design of recirculation system, Fed-batch reactor operation. Uses of Well-defined Mixed Populations- Spoilage and product manufacture by Spontaneous Mixed Cultures; Microbial Participation in the Natural Cycles of Matter. Bioprocessing of recombinant proteins- Tissue plasminogen activator (TPA), Growth hormone, Interferon, Erythroprotein, Insulin.

References:

1. Harvey W. Blanch and Douglas S. Clark. *Biochemical Engineering*, CRC Press, 1997
2. Daan J.A. Crommeline, Robert D. Sindelar and Bernd Meibohm. *Pharmaceutical Biotechnology*, (3e), 2007
3. John Villadsen. *Bioreaction Engineering Principles*. (3e), Springer publishers, 2011

BIO 4060: BIOFUELS ENGINEERING [2 1 0 3]

Various feedstock for different kinds of Biofuels; Biochemical pathways; Life Cycle Analysis (LCA) of various biofuels, Various process technologies for bioethanol production; Microorganism selection; Comparison of various bioethanol processes; Thermodynamic and kinetic aspects of biodiesel production; Biodiesel from Jatropha and Waste cooking oils, Acid base, enzyme catalyzed esterification process; Biodiesel from Microalgae and various contemporary technologies and their comparisons; Hydrogen production by enzymes and various microorganisms, Inhibition effects of Hydrogen; Biochemical basis of microbial fuel cells; single cell and two cell designs; basic calculations of power and efficiency; Biogas production from various sources.

References:

1. Caye M. Drapcho, Nghiem Phu Nhuan and Terry H. Walker. *Biofuels Engineering Process Technology*, McGraw Hill Publishers, 2008
2. Jonathan R. Meilenz. *Biofuels – Methods and Protocols (Methods in Molecular Biology Series*, Humana Press, 2009
3. Lisbeth Olsson. *Biofuels (Advances in Biochemical Engineering/Biotechnology Series)*, Springer-Verlag Publishers, 2007

BIO 4061 BIOPROCESS EQUIPMENT DESIGN [2 1 0 3]

Design of Pressure Vessels: Codes and standards, design factors, design of vessels under internal and external pressure. Design of fermentors: Mixing in Fermenters, Power Requirements. Design criteria for batch fermentor, chemostat and bubble column fermentor, scale up of fermentors. Heat Exchanger Design: Type of heat exchangers, energy balances in heat exchanger, Heat transfer in fermentors, process design of shell and tube heat exchangers. Evaporator design: Evaporation – types of evaporators – Enthalpy balances in single and multiple evaporators – economy and capacity of evaporator. Process design of triple effect evaporators.

References:

1. Richardson, and Sinott R.K. *Chemical Engineering Vol. 6*, J.F. Pergamon Press, 2005
2. Joshi M.V. *Process Equipment Design*, McMillan India, 2005
3. Stanbury P.F., Hall S., *Whitaker* A. *Principles of Fermentation Technology*, (2e), Elsevier Science Publishers, 2003
4. Bjorn K. Lydersen, Nancy A D'elia and Kim L. Nelson. *Bioprocess Engineering-Systems, Equipment and Facilities*, A Wiley Interscience Publication, 1994
5. Unfired Pressure Vessel Code BIS 2825
6. Code for Shell & Tube heat exchangers BIS 4503
7. Chemical Engineer's Handbook by Perry

BIO 4062: BIOSENSORS [2 1 0 3]

Principles of Biomolecular Recognition, Surface Sensitization Techniques and Recognition Receptors Immobilization on Biosensors and Microarrays, Analytical Tools for Biosensor Surface Chemical Characterization, Enzyme for Biosensing Applications, Antibodies in Biosensing, Peptides as Molecular Receptors, Carbohydrates as Recognition Receptors in Biosensing Applications, Nucleic Acid Diagnostic Biosensors, Tissue-Based Biosensors, Biosensing with Plants: Plant Receptors for Sensing Environmental Pollution, Bacteriophage-Based Biosensors,

Antibody Engineering for Biosensor Applications, Genetically Engineered Proteins as Recognition Receptors, Biosensing Systems Based on Genetically Engineered Whole Cells, Photosynthetic Proteins Created by Computational and Biotechnological Approaches in Biosensing Applications, Oligonucleotides as Recognition and Catalytic Elements, Aptamers: Versatitle Tools for Reagentless Aptasensing, Phage Display Technology in Biosensor Development, Molecularly Imprinted Polymer Receptors for Sensors and Arrays.

References:

1. Victor Yang and NGO T.T. *Biosensors and their applications*. Springer, 2000
2. Mohammed Zourob. *Recognition Receptors in Biosensors*. Springer, 2010

BIO 4063: BIOSTATISTICS AND DESIGN OF EXPERIMENTS [2 1 0 3]

Introduction to statistics: Descriptive and inferential statistics. Measures of central tendency Measures of spread. Probability distributions, Hypothesis testing. Linear & quadratic models, regression coefficients, estimation using least squares method. Introduction to statistical design: Introduction to factorial designs, 2k factorial design, main effects, interaction effects Screening designs: Fractional factorial designs, Plackett-Burmann screening designs. Model reduction, model assumption checking, residual plots. Optimization designs: Response surface methodology – concepts & methods, central composite designs and Box-Behnken design.

References:

1. Montgomery Douglas C. *Design and analysis of experiments*, John Wiley, 2012
2. Lawson John & Erjavec John. *Modern Statistics for Engineering and Quality Improvement*, Thomson, 2001
3. Panda T., Theodore T. and Kumar R.A. *Statistical Optimization of Biological Systems*. CRC Press, 2015
4. Rosner B. *Fundamentals of Biostatistics*, (5e), Duxbury Thomson Learning, 2000

BIO 4064: COMPUTATIONAL BIOLOGY [2 1 0 3]

Algorithms and complexity, Biological algorithms versus Computer algorithms, Algorithm design techniques, Data mining, Data storage and retrieval, Machine learning, Biological data mining tools, Introduction to SQL, Bio-Perl and Bio-Java, Sequence alignment: Dynamic Programming algorithm, Multiple sequence alignment methods, Similarity Search Algorithms, Identification of functional sites in molecules, Pattern matching, Profiles and Hidden Markov Models, Gene and

promoter prediction, Identification of regulatory elements in promoters, Protein motifs and domain prediction, Restriction Mapping, Clustering, Gene expression analysis through clustering, Phylogenetic analysis, Distance based methods, Character based methods, Protein secondary structure prediction methods and algorithms, RNA structure, RNA secondary structure prediction, Case studies.

References:

1. Neil Jones and Pavel Pevzner. *An Introduction to Bioinformatics Algorithms*. MIT Press, 2004
2. Heitor Silvério Lopes and Leonardo Magalhães Cruz. *Computational Biology and Applied Bioinformatics*. InTech, 2011

BIO 4065: FOOD PROCESS ENGINEERING AND TECHNOLOGY [2 1 0 3]

Introduction to Food Processing-: Biotechnology in relation to the food industry; nutritive value of food; types of microorganisms associated with food. Food processing chemistry, Food Spoilage & Preservation- Microbial Spoilage of Vegetables, Fruits, Fresh and Processed Meats, Poultry and Seafood. Food-borne illnesses. Food Preservation-Food Preservation Using Irradiation, Food Preservation with Low Temperatures, Food Preservation with High Temperatures, Preservation of Foods by Drying. Food engineering-Unit operations applied to the food processing industry – Fluid flow applications, Heat transfer applications, Centrifugation, Filtration, Extraction, Membrane separations, Evaporation, Distillation, Absorption, Size reduction, Mixing, Drying, and Crystallization Food Industry- Basal metabolic rate, influences on nutritional status, dietary strategies for individuals, diet for specific groups, Market Place, ecologically sustainable production, risks and benefits of biotechnology to food industry.

References:

1. Roger A., Gordon B. and John T. *Food Biotechnology*. Cambridge University Press, 1989
2. James Jay. *Modern food Microbiology*. Kluwer Academic Publishers, 1992
3. Lindsay W. *Biotechnology – Challenges for the flavor and food industry*. Elsevier Applied Science, 1988

   Earle R.L. *Unit operations in food processing*. Pergamon Press, 1983

BIO 4066: GENOMICS AND PROTEOMICS [2 1 0 3]

Genes and Proteins, unicellular genomes, Metazoan Genomes, Gene, Evolution of Genomes.Sequencing& Genome Projects – preparing genomic DNA for sequencing, Sanger

Dideoxy method, Fluorescence method, shot-gun approach.Genomics– ESTs, SNPs, DNA Chips.Proteomics – protein isolation, purification and quantification.Bioinformatics analysis – clustering Methods, proteome functional information and Protein Chip interaction detection.Genome Management in Eukaryotes – Multicellularity, cell differentiation and gene regulation.Bioinformatics and Functional Genomics – Bioinformatics Approaches to Gene Expression, Microarray data analysis, Human genome and disease identification, OMIM.Comparative genomics.

References:

1. John R.S. Finchman. *Genetic Analysis - Principles, Scope and Objectives*. Blackwell Science, 1994
2. Malcolm A. Campbell, and Laurie J. Heyer. *Discovering Genomics, Proteomics and Bioinformatics*. Pearson, 2006

BIO 4067: HEALTH DIAGNOSTICS [2 1 0 3]

Introduction to Health diagnostics, Importance and applications, Biochemical disorders, Immune disorders, Infectious diseases, Parasitic diseases, Genetic disorders, Chromosomal disorders, single cell disorders and complex traits, Chromosomal disorders, autosomal, sex chromosomal, karyotype analysis. DNA based diagnostics methods, Biochemical diagnostics methods, Cell based diagnostics methods, Antibody markers, CD Markers, FACS, HLA typing, Bioassays, Immunodiagnostics methods, Antigen-Antibody Reactions, Conjugation Techniques, Antibody Production, Case studies related to bacterial, viral and parasitic infections , Diagnosis of infectious diseases, respiratory diseases, Viral disease, bacterial diseases, enteric diseases, parasitic diseases and mycobacterium diseases , Phage display, immunoarrays and FACs.

References:

1. Patrinos G.P., Ansorge W.J. and Danielson P.B. *Molecular Diagnostics*, Academy Press, 2016
2. Burtis C.A. and Bruns D.E. Tietz. *Fundamentals of clinical chemistry and molecular diagnostics*. Elsevier Health Sciences, 2014
3. Tille P. *Bailey & Scott's diagnostic microbiology*. Elsevier Health Sciences, 2015
4. Crocker J. and Burnett D. *The Science of laboratory diagnosis*. John Wiley & Sons, 2005

BIO 4068: METABOLIC ENGINEERING [2 1 0 3]

Introduction – Jacob Monod model, catabolite regulation, glucose effect, cAMP deficiency, feedback regulation. Synthesis of Primary Metabolites –Alteration of feedback regulation, limiting accumulation of end products, metabolites. Biosynthesis of Secondary Metabolites –Precursor effects, prophophase, idiophase relationship, enzyme induction & producers of secondary metabolites. Bioconversions – Advantages, specificity, yields, co-metabolism, avoidance of product inhibition, mixed or sequential bioconversions, conversion of insoluble substances. Regulation of Enzyme Production – Strain selection, improving fermentation, recognizing growth cycle peak, catabolite repression, mutants resistant to repression.

References:

1. Wang D.I.C., Cooney C.L., Demain A.L., Dunnil P., Humphery A.E., Lilly M.D. *Fermentation and Enzyme Technology*. John Wiley and Sons, 1979
2. Stanbury P.F., and Whitaker A. *Principles of Fermentation Technology*. Butterworth Heinemann**,** 1999

BIO 4069: BIOPROCESS MODELING & SIMULATION IN BIOTECHNOLOGY [2 0 3 3]

Perspective on modeling of physical, chemical & biological phenomena, uses and limitations of mathematical models; Examples involving algebraic, ordinary differential, difference, cpartial differential, integral & integro-differential equations; Probability theory, stochastic models parameter estimation model forms for parameter estimation. Parameter estimation using moments, design of experiments; Accuracy of parameter estimates. Design of experiments for model discrimination; Non-linear systems; Plane analysis in classical bioreactor models; Nonlinear dynamics; Chaotic behavior, cob web diagrams, stability of fixed point solutions. Bifurcations behavior, Chaos; Lorenz equations; Population balance modeling, Budding of yeast population – Modeling of cells with dynamic morphology – Modeling for biological populations with correlation between life spans of siblings. Modeling of Industrial sterilization processes.

Laboratory experiments are based on simulation of various bioprocesses using MATLAB.

References:

1. Wayne Bequette B. *Process dynamics modeling and analysis and simulation,* Prentice Hall Inc., 2004

2. John H. Seinfeld and Leon Lapidus. *Mathematical Methods in Chemical Engg., Process Modeling, Estimations and Identification*. Prentice Hall, 1974

BIO 4070: PROTEIN ENGINEERING [2 1 0 3]

Structure of Proteins – Primary, secondary structure prediction and determination super secondary structure, protein folding pathways, tertiary structure and domain in proteins, quaternary structure, methods to determine tertiary and quaternary structure, post transnational modification. Protein Engineering and Design – Methods of protein isolation, purification and quantitation, use of peptides in biology, methods of detection and analysis of proteins. Protein database analysis, methods to alter primary structure of proteins, examples of engineered proteins, protein design, principles and examples.

References:

1. Moody P.C.E. and Wilkinson A.J. *Protein Engineering*, ILR Press, 1990
2. Creighton T.E. *Proteins*. Freeman, 1993

BIO 4071: SOLID STATE FERMENTATION [2 1 0 3]

Scope of solid State fermentation & applications. Macroscopic and microscopic phenomena. Bioreactor types and Selection – Classification and Criteria. Transport phenomena and the scale up. Unaerated and Unmixed bioreactors -Trays, Forcefully-Aerated Bioreactors without Mixing, Packed beds, Rotating and stirred drum bioreactors, Continuously mixed and intermittently-mixed bioreactors. Fundamentals of Modelling of Bioreactor – Methodology, Kinetic sub model, Modelling of effect of temperature, water activity on growth, Death kinetics, Modelling of Heat and Mass transfer and the estimation of transfer coefficients.

References:

1. Mitchell D.A., Krieger N., Berovic M. *Solid State Fermentation Bioreactors Fundamentals of Design and Operation.* Springer Publication, 2006
2. Ashok Pandey, Carlos Ricardo Soccol, Christian Larroche. *Current Developments In Solid-state Fermentation*, Asiatech Publishers, 2007

OPEN ELECTIVES

BIO 4301: BIOLOGICAL DATABASES AND BIOLOGICAL DATA MINING [3 0 0 3]

Central dogma of biology, Data to information, Information flow, Different types of biological data, Storage of data, Database structures, Data representation, File formats, Biological data life cycle, Data management, Sequence databases, Sequence motif databases, Structural databases, Interaction databases, Enzyme databases, Pathway databases, Molecular disease databases, Biomedical literature database, Gene expression database, Immunological databases, Data retrieval, Search engines, Search algorithms, Biological data for mining, Biological information/treasure, Data mining methods, Machine learning, Biological data mining tools, Comparison through alignment, Scoring methods, Profiles, Pattern recognition and discovery, Pattern matching, Data mining through network construction and analysis, SQL, Bio-Perl, Bio-Java, Introduction to structure visualization and simulation tools.

References:

1. Bryan Bergeron. *Bioinformatics Computing*. Prentice Hall, 2002
2. Hui-Huang Hsu. *Advanced data mining technologies in bioinformatics.* Idea Group
3. Publishing, 2006
4. Neil Jones and Pavel Pevzner. *An Introduction to Bioinformatics Algorithms*. MIT
5. Press, 2004
6. Pierre Baldi, Soren Brunak. *Bioinformatics: the machine learning approach*. MIT Press, 2001

BIO 4302: INTRODUCTION TO BIOFUELS AND BIOPOLYMERS [3 0 0 3]

Renewable energies and significance of biofuels, feedstocks for various biofuels, Life Cycle Analysis (LCA) of biofuels, ethanol from fermentation and comparison of different technologies, diesel from Jatropha, waste cooking oils, and Microalgae, biogas and biological hydrogen, and basic concepts of microbial fuel cells; introduction to biopolymers, Biopolymers vs. Synthetic polymers; Synthesis of biopolymers such as Starch, Hemicellulose etc, Commercially available biopolymers, uses of biopolymers, Manufacturing technologies, Fillers & Reinforcement, Market & Economics, Biodegradability.

References

1. Mohanty A.K., *et al. Natural Fibers, Biopolymers, and Biocomposites*, CRC Press, 2005
2. Johnson R.M., Mwaikambo L.Y. and Tucker, N. *Biopolymers,* Rapra technology, 2003

3. Caye M. Drapcho, Nghiem Phu Nhuan and Terry H. Walker. *Biofuels Engineering Process Technology*, McGraw Hill Publishers, 2008

BIO 4303: INTRODUCTION TO BIOINFORMATICS [3 0 0 3]

Introduction to Bioinformatics, Central dogma of biology, Digital code of life, database sequence search & Alignment, The evolutionary basis of sequence alignment, The modular nature of proteins, Optimal alignment methods, Substitution scores and gap penalties, Statistical significance of alignments, Structure file formats; Visualizing structural information, Motifs and Pattern, Protein structure prediction, Searching for trees, Rooting trees, Evaluating trees and Data, Phylogenetic software, Phylogenetics on the web, Some simple practical considerations, Genome annotation, Comparative genomics, Genome compression.

References:

1. Arthur M. Lesk. *Introduction to Bioinformatics*. Oxford University Press, 2002
2. Stuart M. Brown. *BIOINFORMATICS: A biologists guide to biocomputing and the internet*. NYU Medical Center, 2000