I SEMESTER M.Tech [Industrial Biotechnology]

MAT 5158: MATHEMATICAL AND NUMERICAL TECHNIQUES IN CHEMICAL AND BIOLOGICAL ENGINEERING [3104]

MAT 5158	MATHEMATICAL AND NUMERICAL TECHNIQUES IN CHEMICAL AND BIOCHEMICAL ENGINEERING	PO1	PO2	PO3	PO4	PO5	PO6
MAT 5158.1	Solve the system of linear equations by direct and iterative methods and learn different methods for finding eigen values and eigen vectors.	3			3		
MAT 5158.2	Learn numerical integration and understand concept of regression analysis, orthogonal polynomials and least square approximation for continuous functions.	3			3		
MAT 5158.3	Solve algebraic and transcendental equations using numerical methods	3			3		
MAT 5158.4	Solve differential equations using finite difference and finite element methods.	3			3		
MAT 5158.5	Know the concept of multivariate nonlinear optimization without constraints.	3			3		
	Average	3	0	0	3	0	0

Solution of system of linear equations by direct and iteration methods., Eigen values and Eigen vectors of Matrices by iterative methods, Rayleigh's Power method, Numerical Integration by composite integration methods, Regression-Linear, Polynomial, multiple linear, Non-linear regression, Orthogonal polynomials and functions. Algebraic and transcendental equations-Iterative methods. Numerical solution of differential equations-Initial value problems and boundary value problems- Single and multistep methods. Multivariate non-linear optimization without constraints

References:

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for scientific and engineering computation, New age international (P) Limited, Publishers.
2. SanthoshK.Gupta, Numerical methods for Engineer, Wiley Eastern Ltd, New Delhi.

HUM 5151 RESEARCH METHODOLOGIES AND TECHNICAL COMMUNICATION [1 0 3 2]

Mechanics of Research Methodology; Basic concepts: Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, Data collection using questionnaire, Interviewing, and experimentation; Research formulation: Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good research problem; Research hypothesis: Criterion for hypothesis construction, Nature of

hypothesis, Need for having a working hypothesis, Characteristics and Types of hypothesis, Procedure for hypothesis testing; Sampling Methods: Introduction to various sampling methods and their applications; Data Analysis: Sources of data, Collection of data, Measurement and scaling technique, and Different techniques of Data analysis; Thesis Writing and Journal Publication: Writing thesis, Writing journal and conference papers, IEEE and Harvard styles of referencing, Effective Presentation, Copyrights, and avoiding plagiarism.

HUM 5151	**RESEARCH METHODOLOGY AND TECHNICAL COMMUNICATION**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
HUM 5151.1	Define concept of research and recall types of research	3	1				1
HUM 5151.2	Define the problem and develop the research design to solve the problem	3	1	1	1		
HUM 5151.3	Organize a thesis report and a manuscript	3	2		1		
HUM 5151.4	Develop effective technical presentation	3	1	1	1		
HUM 5151.5	Develop a good research proposal	3	2	1	1	1	1
	Average	3	1.4	0	0	0	0

References:

1. Dr Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE, 2005.
2. Geoffrey R. Marczyk, David DeMatteo & David Festinger, Essentials of Research Design and Methodology, John Wiley & Sons, 2004.

BIO 5151 ADVANCED BIOPROCESS ENGINEERING [3 1 0 4]

Structure, properties and classification of carbohydrates, lipids, proteins & nucleic acids; Prokaryotes & Eukaryotes; Bacterial Taxonomy, Microscopy,; Isolation, Preservation and Improvement of Industrial Micro-Organisms; Medium requirement; Sterilization - batch and continuous, filter sterilization. Design of sterilization equipment; Classification of Enzymes; Mechanism of Enzyme Action; Determination of elementary step rate kinetics, patterns of substrate concentration dependence, modulation and regulation of enzyme activity; Phases of cell growth in batch cultures - transient growth kinetics, Simple unstructured kinetic models for microbial growth, Growth of filamentous organisms; Conditions affecting growth kinetics, substrate & product inhibition on cell growth & product formation; structured kinetic models, segregated kinetic models of growth; Material-Balance calculations, Stoichiometry of microbial growth & Product formation, Energy – Balance Calculations with and Without Reactions; A brief outline of processes for the production of some commercially important Organic acids, amino

acids and alcohols, study of production processes for various classes of low molecular weight secondary metabolites: Antibiotics, quinones, aromatics, Vitamins and Steroid.

BIO 5151	ADVANCED BIOPROCESS ENGINEERING	PO1	PO2	PO3	PO4	PO5	PO6
BIO 5151.1	Apply basic concepts and principles in bioprocessing	2	2	2	2	2	1
BIO 5151.2	Analyze and optimize media components and design sterization	2	2	2	3	2	1
BIO 5151.3	Apply principles and derivation involved in enzyme kinetics	2	2	3	3	2	1
BIO 5151.4	Determine the growth kinetics of microorganisms.	2	2	3	3	2	1
BIO 5151.5	Integrate the material balance concept in energy anlaysis of yield coefficients and microbial growth. Impart the knowledge of industrial bioprocesses products	2	2	2	2	2	1
	Average	2	2	2.40	2.60	2	1

References:

1. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts (2e), Prentice Hall, Englewood Cliffs, NJ, 2002.
2. Pauline M Doran, Bioprocess engineering principles (1e), Academic Press, 1995.

BIO 5152 ADVANCED BIOSEPARATION PROCESSES [3 1 0 4]

Role of Downstream Processing in Biotechnology; Economics and downstream processing, Cost cutting, Cell disruption; flocculation, sedimentation, centrifugation and filtration; Precipitation methods; Extraction: Batch, staged - cross current, co current, counter current, Differential, fractional, Aqueous two-phase, Reverse micelle extraction, supercritical fluid extraction, Design & configuration of membrane separation equipment; R.O., dialysis, electro dialysis, IEF; Adsorption isotherms, industrial adsorbents, adsorption equipments for batch and continuous operations, adsorption in fixed beds; Chromatography: Gel filtration, reversed-phase, hydrophobic interaction, ion-exchange, expanded bed adsorption, bio affinity and IMAC, supercritical fluid; Preparation of commercial enzymes: prolyl-t RNA synthetase; intracellular foreign proteins from recombinant *E.coli and* extracellular protease recovery, biosurfactants.

BIO 5152	ADVANCED BIOSEPARATION PROCESSES	PO1	PO2	PO3	PO4	PO5	PO6
BIO 5152.1	Analyze the relationship of product separation techniques to biomolecular properties	2	1	3	2	1	2
BIO 5152.2	Evaluate the different cell disruption techniques, removal of insolubles and precipitation methods	2	1	3	2	1	2
BIO 5152.3	Apply centrifugation, extraction, adsorption techniques for bio-product separation	2	1	3	2	1	2

BIO 5152.4	Apply membrane-based processes and filtration processes for bio-product purification	2	1	3	2	1	2
BIO 5152.5	Demonstrate Chromatographic separation processes for product analysis and purification	2	1	3	2	1	2
	Average	2	1	3	2	1	2

References:

1. Belter P.A, Cussler E and Wei Shan Hu, Bioseparation – Downstream Processing for Biotechnology, Wiley Interscience, 1988.
2. Asenjo and Juan A. Asenjo, Separation Processes in Biotechnology, CRC Press, 1990.

BIO 5153 MOLECULAR BIOLOGY AND r-DNA TECHNOLOGY [3 1 0 4]

Forms of DNA & RNA, Organization of DNA; DNA Replication in Prokaryotes & Eukaryotes, Telomeric Replication; Replication of Viral DNA; Transcription in Prokaryotes & Eukaryotes, Post-transcriptional Modifications, Genetic Code, Wobble Hypothesis, Translation in Prokaryotes & Eukaryotes, Post-translational Modifications; Operons; DNA Repair, Mutations and Mutagenesis; Basics of rDNA Technology; Enzymes in Genetic Engineering; Nucleic Acid Hybridization, Probes & DNA Libraries; Restriction Mapping, Adaptors & Linkers, PCR, RFLP, RAPD, DNA Sequencing; SNPs, VNTRs; Therapeutic proteins from Transgenic plants & animals, Gene Therapy; Recombinant DNA Vaccines; Resistance to Herbicides, virus, insect and pests, Stress tolerance; DNA fingerprinting, Directed mutagenesis, Antisense Technology.

BIO 5153	**MOLECULAR BIOLOGY AND R-DNA TECHNOLOGY**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
BIO 5153.1	Articulate the organization of DNA and replication, transcription and translation mechanisms in prokaryote and eukaryote.	1	3	3	3		
BIO 5153.2	Assess various regulations and its elements that control gene expression.	2	3	3	3		
BIO 5153.3	Evaluate the genetic mutations that lead to genetic diseases	1	3	3	3	2	
BIO 5153.4	Appraise the principles in molecular cloning, expression vectors and their hosts.	3	3	3	3	3	
BIO 5153.5	Apply enzymes in recombinant DNA technology	3	3	2	3	3	
BIO 5153.6	Formulate amplification and manipulation techniques and their applications in diagnosis, drug therapies and plant breeding applications.	3	3	2	3	3	1
	Average	2.17	3	2.67	3	2.75	1

Reference:

1. David Friefelder, Molecular Biology (2e), Jones and Bartlett Publishers Inc, 1987.
2. Benjamin Lewin, Genes VIII , Prentice Hall , 2004.

BIO 5154 TRANSPORT PHENOMENA IN BIOPROCESS ENGINEERING [3 1 0 4]

Introduction to Momentum, heat and mass transfer, Unified equation of momentum heat and mass transfer, Shell Momentum balances and velocity distributions in laminar flow -flow of a falling film, circular tube, flow through an annulus, flow of two adjacent immiscible fluids. The equations of change for isothermal systems, equation of motion and dimensional analysis. Heat conduction and convection in different systems using shell energy balance to find out temperature distribution. Diffusivity and the Mechanisms of Mass Transport, Diffusion through a stagnant gas film, homogeneous and heterogeneous chemical reaction, gas absorption and porous catalyst. Velocity distributions with more than one Independent variable, The equations of change for non-isothermal systems, Temperature distributions with more than one independent variable, Equations of change for multicomponent systems.

BIO 5154	TRANSPORT PHENOMENA IN BIOPROCESS ENGINEERING	PO1	PO2	PO3	PO4	PO5	PO6
BIO 5154.1	Apply shell balance technique for fluid flow and solve momentum transfer problems	1	3	3	1		1
BIO 5154.2	Apply shell balance technique for heat flow in solid liquid and gases and solve heat transfer problems	2	3	3	1		1
BIO 5154.3	Apply shell balance technique to Solve Concentration distributions in solids, liquids and gases	2	3	3	1		1
BIO 5154.4	Apply equation of motion to solve problems	2	3	3	1		1
BIO 5154.5	Solve momentum, heat and mass transfer problems with more than one independent variable	2	3	3	1		1
	Average	1.8	3	3	1	0	1

References:

1. Arthur T. Johnson, Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied to Biological Systems, John Wiley and Sons, 1998.
2. Blanch H.W and Douglas S. C, Biochemical Engineering, CRC Press, 1997.

BIO 5161 BIOPROCESS ENGINEERING LAB [0 0 6 2]

Pure culture techniques, SDS – PAGE of proteins, Microbial growth kinetics, Effect of substrate concentration on kinetics of invertase enzyme, Enzyme immobilization protocol by entrapment method in alginate gel, Deactivation kinetics of invertase enzyme, Studies on mass transfer effects on the performance of enzyme entrapped in alginate gel, Batch recycle immobilized packed bed bioreactor, Continuous flow immobilized enzyme packed bed bio reactor, Fluidized bed bioreactor (FBR) for enzyme kinetics, Batch heat sterilization and thermal death kinetics

BIO 5161	BIOPROCESS ENGINEERING LAB	PO1	PO2	PO3	PO4	PO5	PO6
BIO 5161.1	Apply the culturing techniques and determine the microbial growth kinetics	3	3	2	3	2	2
BIO 5161.2	Design batch heat sterilization of media and analyze separation of proteins using SDS-PAGE	3	3	2	3	2	2
BIO 5161.3	Measure the effects of environmental conditions (pH, temperature, inhibitor concentration) on enzyme kinetics and its stability	3	3	2	3	2	2
BIO 5161.4	Design the immobilized enzyme kinetics and estimate the kinetic parameters for the given enzymatic reaction	3	3	2	3	2	2
BIO 5161.5	Evaluate the performance of various systems of the bioreactor (continuous flow immobilized enzyme bioreactor, fluidized bed reactor, and batch recycle reactor)	3	3	2	3	2	2
	Average	3	3	2	3	2	2

BIO 5162 TISSUE CULTURE AND SEPARATIONS LAB [0 0 3 1]

Characterization of plant cell suspension cultures-cell growth, Cell count, heterogeneity and viability, Isolation, identification and quantification of secondary metabolite berberine from in vitro cultures and field grown plants, Isolation of RNA from Plants, Isolation of RNA from Plants, Organelle isolation and marker enzyme assay, Determining cell viability, Thawing of frozen cell line, Sub-culturing of cells, Ultra-filtration, Size Exclusion Chromatography, Partitioning of Protein

BIO 5162	TISSUE CULTURE AND SEPARATIONS LAB	PO1	PO2	PO3	PO4	PO5	PO6
BIO 5162.1	Predict the media components and growth regulators for plant tissue culture	3		2		1	1
BIO 5162.2	Predict the accumulation of plant pigments and secondary metabolites	3		2		1	1
BIO 5162.3	Evaluation of product purification processes such as filtration and size exclusion chromatography	1	1	2	2	1	

BIO 5162.4	Develop model for cell lysis process for product recovery	1	1	2	2	1	
BIO 5162.5	Analyze the cells and perform required animal cell culture procedures				1	2	3
BIO 5162.6	Examine DNA characterization, amplification and manipulation techniques and their applications in diagnosis, drug therapies and plant breeding applications.	1					3
	Average	2.25	3	2	1.5	1.33	2

II SEMESTER

BIO 5251 BIOPROCESS MODELING, ANALYSIS & SIMULATION [3 1 0 4]

Perspective on modeling of physical, chemical & biological phenomena, uses and limitations of mathematical models; Examples involving algebraic, ordinary differential, difference, partial 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

BIO 5251	**BIOPROCESS MODELING ANALYSIS AND SIMULATION**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
BIO 5251.1	Apply engineering principles to build a model for bioprocess system	3	2	2	3		
BIO 5251.2	Build a model for steady state behavior of bioprocess systems	3	2	2	3		
BIO 5251.3	Employ material and energy balance principles to build a dynamic model	3	2	2	3		
BIO 5251.4	Apply critical thinking and analytical skills to interpret the simulations of bioprocess system	3	2	2	3		
BIO 5251.5	Solve bioprocess models, using advanced mathematical techniques	3	2	2	3		
	Average	3	2	2	3		

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., (Vol. 3), Process Modeling, Estimations and Identification. Prentice Hall, 1974.

BIO 5252 BIOREACTOR DESIGN AND ANALYSIS [3 1 0 4]

Mass transfer effects in heterogeneous reaction system; Chemostat with cell cultures; CSTR with immobilized enzymes, operation of CSTR in constant feed rate policy; Chemostats in series; Plug flow reactor; Performance equation with M-M kinetics, substrate & product inhibition kinetics, PFR for immobilized enzymes, Simulation for conversion; Fed–batch reactor; Stability analysis, Eigen values; Bioreactor control; Controllability matrix; Design of P-controller for Turbidostat & Nutristat operation; Biological waste water treatment with Feed forward control; Various industrial Bioreactors; aeration and oxygen mass transfer in bioreactor system, RTD, E, C ,F-curves, Micro & Macro fluid.

BIO 5252	**BIOREACTOR DESIGN AND ANALYSIS**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
BIO 5252.1	Illustrate the heterogeneous reaction system and predict the mass transfer effects in continuous reactors	3		1			
BIO 5252.2	Design the batch, continuous, Fed-batch, recycle and cascade bioreactor systems for given process	2			3		
BIO 5252.3	Apply the stability analysis to continuous fermenters	3					
BIO 5252.4	Design the controllers for Turbidostat and nutristat operations	2			3		
BIO 5252.5	Perform RTD study for non-ideal reactor and then able to estimate extent of non-ideality in commercial reactors	3		1			
	Average	2.6	0	1	3	0	0

References:

1. Blanch H.W and Douglas S. Clark, *Biochemical Engineering*, CRC Press, 1997.
2. Michael L Shuler and Fikret Kargi, *Bioprocess Engineering: Basic Concepts*, Prentice-Hall of India Pvt Ltd, 2008.

BIO 5261 BIOMOLECULAR DATA ANALYTICS LAB [0 0 3 1]

Information retrieval from databases, Sequence alignment: Pairwise and Multiple sequences, Basics of PERL programming, Primer Design, Protein secondary structure prediction, Structure visualization & analysis, Protein modeling, analysis, and validation, Protein-ligand docking, Protein-protein docking, 3D-printing of biomolecules.

BIO 5261	BIOMOLECULAR DATA ANALYTICS LAB	PO1	PO2	PO3	PO4	PO5	PO6
BIO 5261.1	Examine biomolecular Data using analytics tools	3	2	2	3	1	1
BIO 5261.2	Illustrate and interpret biomolecular data	3	2	3	3	1	1
BIO 5261.3	Analyze Large scale biomolecular Data	3	2	3	3	1	1
BIO 5261.4	Examine protein and ligand interactions	3	2	3	3	1	1
	Average	3	2	2.75	3	1	1

BIO 5262 MODELING, SIMULATION AND CONTROL LAB [0 0 3 1]

Representation of transfer functions and input-output models using Matlab commands, Response plots, stability analysis and design of proportional controller for bioreactor, Performance analysis of fed batch and chemostat reactors –solution for set of differential equations, Performance analysis of bioreactor using Matlab-use of phase plane analysis, Introduction to Simulink and building a dynamic model for fermentation process with Simulink, Design of chemostat using grapher (GUI interface), Flow control trainer, Temperature measurement and calibration of thermometers & first order systems, Non interacting & interacting system, First order & second order system

BIO 5262	MODELING, SIMULATION AND CONTROL LAB	PO1	PO2	PO3	PO4	PO5	PO6
BIO 5262.1	Evaluate steady error, steady state gain and time domain analysis of continuous systems using MATLAB commands	3	2	2	2		
BIO 5262.2	Design Simulink model to analyze dynamic behavior of bioreactors	3	2	2	2		
BIO 5262.3	Design chemostat using Graphical User Interface.	3	2	2	2		
BIO 5262.4	Interpret the dynamics of different thermometers and control valves	3	1	2	2		
BIO 5262.5	Evaluate the parameters of first order, second order, interacting and non-interacting systems.	3	1	2	2		
	Average	3	2	2	2	0	0

SECOND YEAR

BIO 6098 PROJECT WORK [0 0 0 25]

Students are required to undertake innovative and research oriented projects, which not only reflect their knowledge gained in the previous two semesters but also reflects additional knowledge gained from their own effort. The project work can be carried out in the institution/ industry/ research laboratory or any other competent institutions. The duration of project work should be a minimum of 36 weeks. There will be a mid-term evaluation of the project work done after about 18 weeks. An interim project report is to be submitted to the department during the mid-term evaluation. Each student has to submit to the department a project report in prescribed format after completing the work. The final evaluation and viva-voice will be after submission of the report. Each student has to make a presentation on the work carried out, before the departmental committee for project evaluation. The mid-term & end semester evaluation will be done by the departmental committee including the guides.

BIO 6098	**PROJECT WORK**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
BIO 6098.1	Construct a scientific research plan to execute and finish within a stipulated timeframe	2		2	2	1	1
BIO 6098.2	Apply the SOPs and adhere to GLP	2		2		1	
BIO 6098.3	Analyze and report the results from the practical research exercise		3	1	2	3	
BIO 6098.4	Operate in a group with team spirit	1					2
	Average	1.67	3	1.67	2	1.67	1.5