BMS COLLEGE OF ENGINEERING, BENGALURU

DEPARTMENT OF CHEMICAL ENGINEERING

M.TECH. BIOCHEMICAL ENGINEERING

CHOICE BASED CREDIT SYSTEM (CBCS)

SCHEME OF TEACHING AND EXAMINATION

M. Tech Biochemical Engineering

Batch Admitted 2016

Department Vision

Be a globally recognized Chemical Engineering Department by imparting quality education

Department Mission

- High-quality education and experience to the budding Chemical Engineers
- Chemical Engineering graduates to assume positions in process and other allied industries
- Foster and encourage the pursuit of excellence in chemical science and engineering
- Inculcate global research potential

Program Educational Objectives of the PG program

PEO 1	Graduates pursue profession in biochemical engineering
PEO 2	Graduates work in multidisciplinary group
PEO 3	Graduates will pursue higher education & research

GRAUDATE ATTRIBUTES FOR PG PROGRAMMES

Graduates Attributes (GAs) form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The GAs of the PG programme are exemplars of the attributes expected of a graduate of an accredited programme. The Graduate Attributes of the PG programme of the NBA are as following:

1. **Scholarship of Knowledge:** Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyses and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. **Critical Thinking:**Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
3. **Problem Solving:** Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those

problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

4. **Research Skill:**Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyses and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
5. **Usage of modern tools:** Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.
6. **Collaborative and Multidisciplinary work:**Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
7. **Project Management and Finance:** Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.
8. **Communication:**Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
9. **Life-long Learning:**Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
10. **Ethical Practices and Social Responsibility:** Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
11. **Independent and Reflective Learning:** Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

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I Semester **CREDIT BASED**

Subject Code	Name of the Subject	Credits				Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		L	T	P	S		I.A.	Exam		
16CHBCPCPA	Process Automation	3	1	1	0	3	50	50	100	5
16CHBCPCBP	Bioprocess Engineering	3	0	0	0	3	50	50	100	3
16CHBCPCBD	Bio-separation & Downstream Processing	3	0	1	1	3	50	50	100	5
16CHBCPCBR	Bioreactors	3	0	0	1	3	50	50	100	4
16CHBCPEZZ	Elective – 1	3	0	0	0	3	50	50	100	3
16CHBCPEZZ	Elective – 2	3	0	0	0	3	50	50	100	3
16APRDICRM	Research Methodology (INSTITUTE CORE)	2	0	0	0	3	50	50	100	2
Total		**20**	**1**	**2**	**2**	**21**	**350**	**350**	**700**	**25**

Course Elective 1		**Course Elective 2**	
16CHBCPETP	Transport Phenomena in Bioprocess System	16CHBCPEFE	Food Engineering
16CHBCPEMM	Mathematical Modeling in Biochemical Engineering	16CHBCPEET	Enzyme Technology
16CHBCPEOR	Operation Research	16CHBCPEBI	Bioinstrumentation
16CHBCPENA	Numerical Analysis	16CHBCPEBT	Biological Thermodynamics

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II Semester **CREDIT BASED**

Subject Code	Name of the Subject	Credits				Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		L	T	P	S		I.A.	Exam		
16CHBCPCSM	Statistical Methods	3	1	0	0	3	50	50	100	4
16CHBCPCBE	Bioenergy	3	0	0	1	3	50	50	100	4
16CHBCPCRE	Reaction Engineering	3	1	1	0	3	50	50	100	5
16CHBCPEZZ	Elective – 3	3	0	0	0	3	50	50	100	3
16CHBCPEZZ	Elective – 4	3	0	0	0	3	50	50	100	3
16CHBCIEZZ	Institution Elective	4	0	0	0	3	50	50	100	4
16CHBCPCT1	Technical Seminar -1	0	0	2	0	3	50	50	100	2
Total		**19**	**2**	**3**	**1**	**21**	**350**	**350**	**700**	**25**

Elective 3		**Elective 4**		**Institution Elective**	
16CHBCPEBW	Biological Waste Treatment and Engineering	16CHBCPENT	Nanotechnology in Bioprocess Industries	16CHBCIEFT	Fermentation Technology
16CHBCPEBM	Bioprocess Modeling and Simulation	16CHBCPEBS	Biosensors		
16CHBCPEMS	Membrane Separation Technology	16CHBCPESM	Safety Management in Bioprocess Industries	16CHBCIEBM	Biomaterials
16CHBCPEAT	Animal & Tissue Culture Engineering	16CHBCPEBP	Biopharmaceuticals		

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III Semester: INTERNSHIP /INDUSTRIAL TRAINING, PROJECT –I PHASE **CREDIT BASED**

Course Code	Subject	No. of Hrs./Week		Duration of the Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work		I.A.	Exam		
16CHBCPCIN	**Internship/Industrial training: Preliminary Report** submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and the respective Head of the Department.	-		-	25		25	21
	Internship/Industrial training: Final Report submission and Evaluation after 16 week of Internship to be carried out by the Internal Guide of the college and the respective Head of the Department. Report Evaluation to be completed within two weeks of submission	-		-	25		25	
	Viva-Voce on Internship - To be conducted *internally* by the Internship Guide (from the college) and the External Guide/Examiner Within 2 weeks of Submission	-		-		50	50	
16CHBCPCP1	**Project Phase: I** – Problem formulation and submission of synopsis within 8 weeks from the commencement of 3rd semester. Preliminary work on Project Implementation.				50	50	100	04
	Total	**-**		**-**	**100**	**100**	**200**	**25**

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IV Semester **CREDIT BASED**

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Field Work / Tutorials		I.A.	Exam		
16CHBCPCP2	Project Phase-II - Internal Evaluation of Project work in progress (report + presentation on progress /status of project)	-			50		50	23
	Project Phase-III - Project Demonstration /final evaluation of the project by internal guide/faculty (dissertation report final presentation and evaluation).	-			50		50	
	Final Evaluation of Project Work and Viva-voce by internal and external evaluators	–				100	100	
16CHBCPCT2	Technical Seminar-2				50	50	100	02
Total		**-**	**-**	**-**	**150**	**150**	**300**	**25**
Grand Total (I to IV Sem.)								**100 credits**

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M.TECH. IN BIOCHEMICAL ENGINEERING

Overall Scheme of Instruction

I SEM	II SEM	III SEM		IV SEM	
Process Automation 16CHBCPCPA **3-1-1-0 (5)**	Statistical Methods 16CHBCPCSM **3-1-0-0 (4)**	**Internship/Industrial training: Preliminary Report** **Internship/Industrial training: Final Report** **Viva-Voce on Internship** 16CHBCPCIN	**21**	**Project Phase-II** **Project Phase-III** **Final Evaluation of Project Work and Viva-voce** 16CHBCPCP2	23
Bioprocess Engineering 16CHBCPCBP **3-0-0-0 (3)**	Bioenergy 16CHBCPCBE **3-0-0-1 (4)**				
Bio-separation & Downstream Processing 16CHBCPCBD **3-0-1-1 (5)**	Reaction Engineering 16CHBCPCRE **3-1-1-0 (5)**				
Bioreactors 16CHBCPCBR **3-0-0-1 (4)**	**Elective – 3** **3-0-0-0 (3)** Biological Waste Treatment and Engineering 16CHBCPEBW	**Project Phase: I** 16CHBCPCP1	04	Technical Seminar -2 16CHBCPCT2	02
	Bioprocess Modeling and Simulation 16CHBCPEBM				
	Membrane Separation Technology 16CHBCPEMS				
	Animal & Tissue Culture Engineering 16CHBCPEAT				
Elective – 1 **3-0-0-0 (3)** Transport Phenomena in Bioprocess System 16CHBCPETP	**Elective – 4** **3-0-0-0 (3)** Nanotechnology in Bioprocess Industries 16CHBCPENT				
Mathematical Modeling in Biochemical Engineering 16CHBCPEMM	Biosensors 16CHBCPEBS				
Operation Research 16CHBCPEOR	Safety Management in Bioprocess Industries 16CHBCPESM				
Numerical Analysis 16CHBCPENA	Biopharmaceuticals 16CHBCPEBP				
Elective – 2 **3-0-0-0 (3)** Food Engineering 16CHBCPEFE	**Institution Elective** **4-0-0-0 (4)** Fermentation Technology 16CHBCIEFT				
Enzyme Technology 16CHBCPEET	Biomaterials 16CHBCIEBM				
Bioinstrumentation 16CHBCPEBI					
Biological Thermodynamics 16CHBCPEBT					
Research Methodology (INSTITUTE CORE) 16APRDICRM **2-0-0-0 (2)**	Technical Seminar -1 16CHBCPCT1 **2-0-0-0 (2)**				
TOTAL 25	**25**	**25**		**25**	

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M.TECH. IN BIOCHEMICAL ENGINEERING

FIRST SEMESTER M.TECH – BIOCHEMICAL ENGINEERING

PROCESS AUTOMATION- 16CHBCPCPA

Subject Code	:	16CHBCPCPA	LTPS	:	3-1-1-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	05			

COURSE OUTCOMES:

- CO 1 Analyze complex engineering problems and apply independent judgment for solving control problem involving open and close loops
- CO 2 Evaluate the stability for open loop systems using modern tools and apply the same for the process of modeling
- CO 3 Usage of modern tools and mathematical techniques in devising control systems involving simple alarms, relays and predict its performance
- CO 4 Evaluate the overall performance of the controllers by applying various inputs for discrete systems.
- CO 5 Analyze, experiment and interpret the stability of control systems by team

Module 1	Time (hrs)
REVIEW OF SYSTEMS: Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Controller- P, PI, PD and PID modes. Control valve types- linear, equal percentage and quick opening valves. Transient response. Block diagrams.	09
Module 2	
STABILITY ANALYSIS: Routh Hurwitz method, Root locus method, Frequency response, design of control system, controller tuning and process identification. Zigler-Nichols and Cohen-Coon tuning methods, Bode-Nyquist Plots-Process modeling.	09
Module 3	
SPECIAL CONTROL TECHNIQUES: Advanced control techniques, cascade, ratio, feed forward, adaptive control, selective controls, Smith predictor, internal model control, theoretical analysis of complex processes.	07
Module 4	
MULTIVARIABLE CONTROL: Analysis of multivariable systems, Interaction, examples of storage tanks. Review of matrix algebra, Bristol arrays, Niederlinski index – Tuning of multivariable controllers.	07
Module 5	
SAMPLE DATA CONTROLLERS: Basic review of Z transforms, Response of discrete systems to various inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems.	07

PROCESS AUTOMATION LABORATORY

NOTE: ANY FIVE EXPERIMENTS

LIST OF EXPERIMENTS

1. Time constant of a Thermometer response
2. Second Order system U Tube Monometer
3. Single Tank – Step response
4. Interacting tanks- Step Response
5. Interacting tanks Pulse Response
6. Non-Interacting tanks- Step Response
7. Non-Interacting tanks- Pulse Response
8. P, PI and PID controller trainer
9. Valve characteristics

TEXT BOOKS:

1. Coughnour D R, "Process system analysis and control", 2nd edn., McGraw Hill, New York, 1991.
2. George Stephanopoules, "Chemical process control, An Introduction to Theory and Practical" - Prentice Hall, New Delhi, 1998.

REFERENCE BOOKS

1. Smith C A and Corripio A B **"**Principles and practice of automotive process control**",** John Wiley, New York, 1976.
2. Luyben**"**Process Modelling, Simulation and Control for chemical Engineers**"** 2nd edn. McGraw Hill, 1990.

BIOPROCESS ENGINEERING- 16CHBCPCBP

Subject Code	:	16CHBCPCBP	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1. To provide the fundamental background of biological systems
CO 2. Emphasize areas of biochemical processes, essential to an engineer to work in the area of bioprocessing.
CO 3. To develop skills in the materials selection which can be utilized within the courses such as bioprocess equipment's design, engineering experimental investigations, process design project and experimental research project throughout the program.

Module 1	Time (hrs)
INTRODUCTION: Bioprocess development an interdisciplinary challenge, introduction to engineering calculations, presentation of analysis of data, regulatory constraints for bioprocess engineering.Bioprocess engineering and technology. Role of a Chemical engineer in a bioprocess	07

industry. Classification of micro-organisms, Taxonomy, Environmental and Industrial microbiology.	
Module 2	
ENZYMES: Introduction, definition and enzyme classification, enzyme kinetics, various models, Experimentally determining rate parameters for MM Kinetics, complex enzyme kinetics, effect of pH and temperatures, insoluble substrates, Numerical on enzymatic Kinetics	09
Module 3	
IMMOBILISED ENZYME SYSTEMS: methods and limitation of immobilization, Effects of diffusion and reaction on kinetics of immobilized enzymes, Effect of other environmental parameters like pH and temperature. Numerical on Immobilized enzymatic Kinetics	07
Module 4	
GROWTH KINETICS OF MICROORGANISMS: Growth Kinetics of Microorganisms: Transient growth kinetics (Different phases of batch cultivation). Quantification of growth kinetics: Substrate limited growth, Models with growth inhibitors, Logistic equation, Filamentous cell growth model. Continuous culture: optimum dilution rate in an ideal Chemostat. Introduction to fed-batch reactors. Immobilized Cells: Formulations, Characterization and Applications	07
Module 5	
MIXED CULTURES: Introduction to mixed cultures, Major Classes of Interactions: Simple Models, Competition between two species, Prey-Predator system, Lotka-Volterra Model **INDUSTRIAL BIOPROCESS:** Anaerobic process: Ethanol, lactic acid, acetone-butanol production. Aerobic Processes: Citric Acid, Baker's Yeast, Penicillin, High fructose corn syrup production.	09

TEXT BOOK:

1. Shuler M. L. and Kargi F.,**"**Bioprocess Engineering", 2nd edn., Prentice Hall,2002.
2. Pauline M. Doran,"Bioprocess Engineering**"**, 2nd edn., Academic Press, 2012.

REFERENCE BOOKS:

1. James E.Bailey and David F.Ollis,"Biochemical Engineering Fundamentals",Mc-Graw Hill, 6th edn., 2005.
2. James Lee, "Biochemical Engineering", Prentice Hall, 1992.
3. Pelczar, "Microbiology Concept and Application",5th edn., McGraw Hill, 2001

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SCHEME OF TEACHING AND EXAMINATION 2016-2017

M.TECH. IN BIOCHEMICAL ENGINEERING

BIOSEPARATION AND DOWNSTREAM PROCESSING- 16CHBCPCBD

Subject Code	:	16CHBCPCBD	LTPS	:	3-0-1-1
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	05			

COURSE OUTCOMES:

CO 1. Reinforce the knowledge of bio-separations, analyze the problems associated with bio-separation based on the physicochemical properties of the biomolecules and to apply to the real world applications.

CO 2. To inculcate critical thinking to analyze complex problems related to separation techniques as well as to evaluate and analyze the applicability of the separation techniques associated with the particular separation process.

CO 3. Assess the purity of the desired product using modern tools; select an appropriate separation process considering the economics and process feasibility.

CO 4. Design a suitable a suitable polishing and packaging operation with consideration of the market economics and shelf life of the product.

CO 5. To demonstrate the collaborative work, develop research skills by conducting experiments on isolation, separation & purification of biomolecules using modern tools.

Module 1	Time (hrs)
INTRODUCTION: Role and importance of downstream processing in biotechnological processes. Problems and requirements of byproduct purification. Economics of downstream processing in Biotechnology. Cost cutting strategies, Characteristics of biological mixtures, Process design criteria for various classes of byproducts (high volume, low value products and low volume, high value products), Physico-chemical basis of different bio-separation processes.	07
Module 2	
PRIMARY SEPARATION TECHNIQUES: Cell disruption methods for intracellular products, removal of insolubles, biomass (and particulate debris) separation techniques; flocculation and sedimentation, Centrifugation (ultra and differential) and filtration methods. Solid-liquid separation with theory of batch filtration, Theories of Centrifugal force, equipments and centrifugal filtrations	08
Module 3	
ISOLATION AND PRODUCT PURIFICATION: Extraction: Principles of extraction, batch and staged extraction, differential extraction. Adsorption: Chemistry of adsorption, batch and continuous adsorption. Precipitation: Precipitation methods with salts, organic solvents, and polymers. Electrophoresis: Principle and Applications of Electrophoresis - their types, Iso-electric focusing	08
Module 4	
MEMBRANE SEPARATION PROCESSES: Membrane – based separations theory; Design and configuration of membrane separation equipment; Applications: Use of membrane diffusion as a tool for separating and characterizing naturally occurring polymers; enzyme processing using ultra filtration membranes; separation by	08

solvent membranes; reverse osmosis.	
Module 5	
FINISHING OPERATIONS AND FORMULATIONS: Finishing operations: Crystallization: Basic concepts, crystal size distributions, batch and recrystallization; Drying: Basic concepts, drying equipment;Lyophilization:Principle of lyophilization, working and applications of lyophilization and formulations	08

DOWNSTREAM PROCESSING LABORATORY

NOTE: ANY FIVE EXPERIMENTS

LIST OF EXPERIMENTS

1. SDS PAGE Electrophoresis
2. Aqueous two phase extraction
3. Ion exchange Chromatography
4. Ammonium sulphate precipitation of proteins
5. Leaf filter
6. Plate and frame filtration
7. Coagulation Jar Test

DEMONSTRATION OF THE EQUIPMENT :

1. Solvent distillation using Rotovap
2. Identification of microorganism using microscope
3. Cell disruption using Deep Freezer &Sonicator
4. Cell separation using Cold Centrifuge

BOOKS:

1. Belter PA, Cussler E and Wei Shan Hu, "Bioseparation"Downstream processing for biotechnology, John Wiley & Sons, New York.1988.
2. Roger G Harrison,"Bioseparataions: Science and Engineering", Oxford Publications, 2006.

REFERENCE BOOKS

1. Neeraj Mishra, AkhileshDubey, "Bioseparation Technology", CRC Press, 2012.
2. Elliott Goldberg, "Handbook of downstream processing", Blackie Academic and Professional, 1997.
3. Verrall, M.S.,"Downstream processing of natural products: A practical handbook", John Wiley & Sons Ltd., England, UK. 1996.
4. Mulder, M.,"Basic principles of Membrane Technology", Kluwer Acadamic Publishers, Netherlands. 1996.
5. Product Recovery in Bioprocess Technology- BIOTOL Series, VCH,1990.
6. Asenjo J and Dekker M, "Separation Process in Biotechnology", Marcell Dekker Publications,1993.

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BIOREACTORS- 16CHBCPCBR

Subject Code	:	16CHBCPCBR	LTPS	:	3-0-0-1
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	04			

COURSE OUTCOMES:

CO 1 Evaluate and analyze the suitability of a bioreactor selecting from a wide choice of spectrum of bioreactors.

CO 2 Apply the concept of transport processes in biological systems involving oxygen transfer, estimate the oxygen rates and coefficient with appropriate models.

CO 3 Analyze the factors influencing the performance of bioreactors and apply judgment to select control systems to stabilize the parameters effecting the bioreactor performance.

CO 4 Select the suitable modern tools to estimate the performance of the scaled up bioreactors and apply ethically a suitable sterilization process.

Module 1	Hrs.
INTRODUCTION TO BIOREACTORS: Overview of biological reactors: submerged liquid fermentation, solid state fermentation, Understanding of bioreactors: Definition of bioreactor, development of bioreactors, Purpose and importance of bioreactor, Classification of bioreactors, bioreactor for animal cell, plant cell cultivation/culture.	07
Module 2	
TRANSPORT PHENOMENA IN BIOPROCESS SYSTEMS: Gas liquid mass transfer in Cellular Systems. Determination of O_2 transfer rates. Mass transfer of freely rising or falling bodies. Forced Convection Mass Transfer: Overall K_{la} Estimates, and power requirements (review) for sparged and agitated vessels. Other factors affecting K_{la}, Models, Power Consumption and Mass transfer for Non Newtonian fluids.	09
Module 3	
BIOREACTOR OPERATIONS: Common operations of bioreactor, selection and identifications of factors for smooth operations of bioreactors, spectrum of basic bioreactor operations, bioreactor operations for immobilizes systems, plant and animal cell bioreactors operation.	09
Module 4	
CONTROLS IN BIOREACTORS: Control task in bioreactor system, instrumentation in bioreactors, control variables and measurement devices, advanced control technique, consistency checks on measurement, adaptive online optimizations. Online and off line measurements and analytical methods.	07
Module 5	
STERILIZATION AND SCALE UP OF BIOREACTORS: Sterilization of Reactors, Batch Sterilization, Continuous Sterilization, filter and air sterilization. Scale up problems in bioreactors, criteria of scale up, similarity criteria; scale up methods, generalized approaches to scale up.	07

TEXT BOOK:

1. Tapabrata Panda, "Bioreactors Analysis and Design**"**, Tata McGraw Hill Education Pvt. Ltd, August, 2011.
2. James E.Bailey and David F.Ollis"Biochemical Engineering Fundamentals**",**6th edn.,Mc-Graw Hill International Edition, 2005.

REFERENCE BOOK

1. Michael L. Shuler and FikretKargi, "Bioprocess Engineering: Basic concepts", 2nd edn., Prentice Hall, 2002.
2. Pauline M. Doran"Bioprocess Engineering", 2nd edn., Academic Press, 2012.

TRANSPORT PHENOMENA IN BIOPROCESS SYSTEM - 16CHBCPETP

Subject Code	:	16CHBCPETP	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1 Apply continuity equations of change for real problems involving basic mass transfer systems, and problems involving determination of oxygen utilization as well as transfer rates
CO 2 Adjudge applicability of mass transfer correlation to determine coefficients for Newtonian & Non-Newtonian fluids
CO 3 Apply Modeling to estimate the distribution of temperature in solids and fluids flowing in laminar regime
CO 4 Apply appropriate techniques to predict, estimate the concentration distribution in fluids in laminar regime.
CO 5 Estimate the transfer coefficient by relating known to unknown parameters in transfer problems

Module 1	Hrs.
ANALOGIES BETWEEN MOMENTUM, HEAT AND MASS TRANSPORT: Numerical problems using Reynold's, Prandtl's and Chilton & Colburn analogies. Momentum Energy and Mass Transport Newton's law of viscosity (NLV).Newtonian and Non-Newtonian fluids.Fourier's law of heat conduction (FLHC).Fick's law of diffusion (FLD).Effect of temperature and pressure on transport properties of fluids.Numerical problems on the application of Numerical problems on use of NLV, FLHC and FLD	07
Module 2	
EQUATIONS OF CHANGE: Equation of continuity Equation of motion; Navier – Stokes	09

equation. Application of these equations in solving simple steady state problems Gas-Liquid Mass Transfer in Cellular System, Basic Mass- Transfer Concepts, Rates of Metabolic Oxygen Utilization, Determination of Oxygen Transfer Rates, Measurement of $k_l a$' Using Gas-Liquid Reactions, Mass-Transfer for Freely, Rising or Falling Bodies, Mass-Transfer Coefficients for Bubbles and Bubbles Swarms, Estimation of Dispersed Phase Int6erfacial Area and Holdup, Holdup Correlations	
Module 3	
FORCED CONVECTION MASS TRANSFER: General Concepts Dimensionless Groups, Correlations for Mass-Transfer Coefficients and Interfacial Area, Example: Correlations for Maximum (D_c) or Sauter Mean (D_{sm}) Bubbles or Droplet Diameters, Overall $k_l a$' Estimates and Power Requirement for sparged and Agitated vessels, Mass Transfer Across Free Surfaces **FACTORS EFFECTING KLA:** Estimation of diffusivities, Ionic Strength , Surface active agents, Non-Newtonian Fluids, Models and parameters for Non-Newtonian Fluids, Suspensions, Macromolecular Solutions, Power consumption and mass Transfer in Non-Newtonian Fluids, Scaling of Mass Transfer equipment	09
Module 4	
TEMPERATURE DISTRIBUTION IN SOLIDS AND IN LAMINAR FLOW: Different situations of heat transfer: Heat conduction with internal generation by electrical, nuclear, viscous energy sources. Numerical problems using the equations derived in the above heat transfer situations. Heat conduction in a cooling fin: Forced and free convection heat transfer HEAT TRANSFER: Heat Transfer co-relations , Sterilization of gases and liquids by filtration	09
Module 5	
CONCENTRATION DISTRIBUTIONS IN LAMINAR FLOW: Steady state Shell mass balances. General Boundary conditions applicable to mass transport problems of chemical engineering. Diffusion through stagnant gas and liquid films. Equimolar counter diffusion.Numerical problems.	06

TEXT BOOK:

1. Bird, BR,, Stewart W.E.and LightfootE. N., "Transport Phenomena", 2nd edn.,John Wiely and Sons, Singapore, 2009.
2. James E.Bailey and David F.Ollis"Biochemical Engineering Fundamentals",6th edn.,Mc-Graw Hill International Edition, 2005.
3. Fruskey, Fan Yuan David F. Katz, "Transport Phenomena in Biological Systems", 2nd edn.,Pearson Prentice Hall Bioengineering, 2011.

REFERENCE BOOKS:

1. Welty, J.R., C.E. Wicks and R.E. Wilson, "Fundamental of Momentum, Heat and Mass Transfer", John Wiley and Sons, 1976.
2. Sissom L.E. and D.R.Pitts, "Elements of Transport Phenomena", McGraw Hill, New York, 1972.
3. Brodkey R.S. and H.C.Hershey, "Transport Phenomena, A United Approach",McGraw Hill, 1988.

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CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016-2017
M.TECH. IN BIOCHEMICAL ENGINEERING

MATHEMATICAL MODELING IN BIOCHEMICAL ENGINEERING
16CHBCPEMM

Subject Code	:	16CHBCPEMM	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1 To make the students understand physical systems in Chemical and Biochemical engineering.

CO 2 Develop mathematical models for Chemical and Biochemical systems.

CO 3 Solve and analyze process models using different mathematical techniques.

Module 1	Hrs
NUMERICAL TECHNIQUES: Simultaneous linear algebraic equation– Gauss Jordan, Non-linear algebraic equation–Newton Raphson, Ordinary Differential Equation–R-K Method, Numerical Integration–Simpson's 1/3 Rule . Applications:Vapor–Liquidequilibria for binary mixtures, Calculation of Bubble Point Dew point for ideal binary mixture	9
Module 2	
BIOREACTOR: Operational stages in a Bioprocess industry, biochemical reactor, continuous stirred tank bioreactor-process description, mathematical model, fed-batch bioreactor- model development	7
Module 3	
DESIGN: Double Pipe Heat Exchanger (Area, Length and Pressure drop), Shell & Tube Heat Exchanger (Area, Number of tubes, Pressure drop)	7
Module 4	
MODELING: Applications of law of conservation of mass in mixing tank system, equilibrium still and single stage extraction. Heat transfer through multiwall cylinders and spheres, heat transfer in a jacketed vessel, rate expression for series and parallel homogenous first order reactions	9
Module 5	
MATHEMATICAL MODELING AND SOLUTIONS TO THE FOLLOWING: Basic tank model – Level V/s time, batch Distillation–Vapour composition with CSTRs in series	7

TEXT BOOKS:

1. Jenson, V. G. and Jeffreys, F. V., "Mathematical methods in Chemical Engineering",2nd edn., Academic press, Elsevier, India, 2012.
2. PradeepAhuja, "Introduction to Numerical Methods in Chemical Engineering", PHI Learning Pvt. Ltd, New Delhi, 2010.

REFRENCE BOOKS:

1. Gaikwad, R.W, and Dhirendra, "Process Modelling and Simulation", 2nd edn.,Denetted& Co., 2006.

2. Grewal, B. S., "Higher Engineering Mathematics", 40th edn.,Khanna Publishers, Delhi, India, 2009.
3. William. L Luyben, "Process Modeling Simulation and Control for Chemical Engineering", 2nd edn., McGraw Hill, 1990.
4. Jana, Aimya K., "Chemical Process Modelling and Computer Simulation", 2nd edn., PHI Learning Private Limited, New Delhi, India, 2011.

OPERATION RESEARCH 16CHBCPEOR

Subject Code	:	16CHBCPEOR	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No. of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1 Get acquainted to find optimum solution for numerical problems using LPP.
CO 2 Solve assignment, transportation and sequencing problems for its optimal solutions.
CO 3 Illustrate network construction and find its feasible solutions for optimization of societal problems.

Module 1	Hrs
INTRODUCTION: Definition. Scope of operation research. Approach and limitations of O. R. Models. Characteristics and phase of O. R. Linear programming problems: Mathematical formulation of L. P. problems. Graphical solution method.	07
Module 2	
ASSIGNMENT PROBLEMS: Balanced and unbalanced assignment problems. Maximization assignment problems. Travelling salesman problems.	09
Module 3	
TRANSPORTATION PROBLEMS: Basic feasible solutions by different methods. Finding optimal solution. MODI method. Degeneracy. Unbalanced transportation problems. Maximization problems.	09
Module 4	
SEQUENCING: Johnson's algorithm. N jobs machines, n jobs – 3, machines and n jobs – machines without passing sequence. 2 job – n, machines. Graphical solutions.	06
Module 5	
PERT – CPM TECHNIQUES: Network Construction. Determining time estimates and critical path. In network analysis. Variance and probability of completing the project. Calculation of different floats. Project duration. Crashing of simple networks.	08

TEXT BOOKS:

1. S. D. Sharma, "Operation Research", 8th edn.,Kedarnath& Co, 2003.
2. KantiSwaroop, P. K. "Gupta and Manmohan, Operation Research", 9th edn., S Chand & Co. 1999.

REFERENCE BOOKS:

1. L. S. Srinath, "Introduction to Pert and CPM", 3rdedn., East West, 1998.
2. Hospach Buchan and Earnest Koenigberg, Scientific Inventory management, 1989.

NUMERICAL ANALYSIS – 16CHBCPENA

Subject Code	:	16CHBCPENA	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	3			

COURSE OUTCOMES:

CO 1 Develop ordinary and partial differential equations to solve chemical and Biochemical engineering problems.
CO 2 Apply appropriate numerical techniques to solve ODE and PDEs.
CO 3 Analyze error in the solution opt using numerical techniques and minimize the error.
CO4 Apply proper regression and curve fitting method to analyze experimental data.

Module 1	Hrs
ERROR ANALYSIS: Accuracy and precision; Truncation and round-off errors; Error propagation. **REGRESSION AND CURVE FITTING:**Linear regression; Least squares; Total Least Squares; Interpolation; Newton's Difference Formulae; Cubic Splines.	09
Module 2	
SOLUTION OF ALGEBRAIC EQUATIONS: Solution of system of linear equations usingCramer's rule; Gauss Elimination; LU Decomposition; Iterative Methods. Solution of linear and nonlinear equation using Bisection, Secant, Newton-Raphson method.	09
Module 3	
NUMERICAL DIFFERENTIATION AND INTEGRATION: Forward, Backward and central difference for first and second order derivative. Trapezoidal rules; Simpson's rules; Quadrature.	07
Module 4	
ODES: INITIAL VALUE PROBLEMS: Taylor series method, Euler's methods; Modified Euler's method, Runge-Kutta methods; Predictor-corrector methods.	07
Module 5	
ODES: BOUNDARY VALUE PROBLEMS AND PDE: Shooting method; Finite differences;	07

Over/Under Relaxation (SOR). Solution of PDE; Solution of heat conduction equation, Solution of Laplace equation.	

TEXT BOOKS:

1. Kendall E. Atkinson, "An Introduction to Numerical Analysis", 2nd edn.,Wiley India Private Limited, 2008.
2. PradeepAhuja, "Introduction to Numerical Methods in Chemical Engineering", PHI Learning Pvt Ltd, New Delhi, 2010
3. Grewal, B. S., "Higher Engineering Mathematics", 43rd edn., Khanna Publishers, Delhi, India, 2014.

REFRENCE BOOKS:

1. Gupta S.K.,"Numerical Methods for Engineers", New Age International, 1995.
2. Chapra S.C. and Canale R.P. "Numerical Methods for Engineers", 5th edn., McGraw Hill, 2006.

FOOD ENGINEERING - 16CHBCPEFE

Subject Code	:	16CHBCPEFE	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1. Comprehend the physical properties of food and its transportation.

CO 2. Identify sources of contaminants, adulterants with its prevention for safe and healthy food.

CO 3. Discern different technologies involved in food processing & preservation.

CO 4. Select biocompatible packaging and additives for food products.

Module 1	Hrs
INTRODUCTION TO FOOD ENGINEERING: Introduction, properties of food materials: Mechanical, thermal & Electrical properties of food, Rheological models, Water activity, Phase transition phenomena in foods, Properties of Liquids Handling Systems for Newtonian & Non-Newtonian Liquids, Transport of solid foods, Numerical on fluid flow in food processing.	07
Module 2	
FOOD PROCESSING AND PRESERVATION: Food deterioration – Causes. Aims and objectives of preservation and processing. Processing systems: pasteurization and blanching systems, commercial sterilization systems, ultra-high pressure systems; pulsed electric field systems; alternative preservation systems. **FOOD CONTAMINATION AND ADULTERATION:**Types of adulterants and contaminants.	08

Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards. HACCP, FSSAI- The Food Safety and Standards Regulations, 2011	
Module 3	
HIGH-TEMPERATURE PRESERVATION: Introduction to Thermal Processing; Pasteurization; Commercial Sterilization Kinetics of Microbial Death; Thermal Death Time; Heat Transfer in Thermal Processing; Integrated F Value; Numerical; Batch & continuous Retorts for Thermal processing; Cold sterilization: Gamma irradiation; Microwave &Ohmic heating. **LOW-TEMPERATURE PRESERVATION:**Principles of low temperature preservation; freezing rate & freezing point; physical properties of frozen food; food quality during frozen storage; freezing equipment, plate freezer, blast freezer, fluidised bed freezer, scraped surface freezer; cryogenic and immersion freezing; prediction of freezing time using Plank's equation &Nagaoka's equation	08
Module 4	
FOOD ADDITIVES: Introduction and need for food additives. Types of additives – antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-caking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety.	09
Module 5	
PACKAGING CONCEPTS: Introduction to packaging; food protection; product containment, commutation; convenience; mass transfer in packaging materials; permeability of packaging material to "fixed" gases; innovations in food packaging; passive packaging; active packaging; intelligent packaging; food packaging and product shelf-life. Advances in aseptic processing and packaging, nutrition labeling.	07

TEXT BOOKS

1. Paul Singh and Dennis R. "Introduction to Food Engineering", Elsevier Science and Technology, 5th edn., 2013.

REFERENCES:

1. HoshaliS. Ramaswamy and Michele Marcotte, "Food Processing: Principles and Applications", CRC Press.
2. ZekiBerk, "Food Process Engineering and Technology", Elsevier Science and Technology, 2009.
3. G. Subbulakshmi and Shobha A. Udupi, "Food Processing and Preservation", New Age International, 2001.

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M.TECH. IN BIOCHEMICAL ENGINEERING

ENZYME TECHNOLOGY- 16CHBCPEET

Subject Code	:	16CHBCPEET	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES

CO 1 Understand the basics and mechanisms of enzyme catalysis
CO 2 Impart knowledge on reaction kinetics of free and immobilized enzymes
CO 3 Study about the industrial applications of enzymes in biological preparation
CO 4 Study instrumental techniques available for using enzymatic analysis.

Module 1	Hrs.
STRUCTURES AND FUNCTIONS OF PROTEINS: Enzyme classification, based on structure classification of amino acids, classifications of proteins, specificities of enzyme action, biosynthesis and properties of proteins.	8
Module 2	
KINETICS: Chemical mechanisms of enzyme catalysed reactions, introduction to bioenergetics and kinetics, kinetics of multi-substrate bioreactions, investigations of active sites structures.	8
Module 3	
CHEMICAL NATURE OF ENZYME CATALYSIS: Sigmoidal kinetics and allosteric enzymes, co-enzymes, significance of sigmoidal behaviour.	8
Module 4	
APPLICATIONS: Investigation of enzymes in biological preparation, extraction and purification, enzymes as analytical reagents	7
Module 5	
INSTRUMENTAL TECHNIQUES: Instrumental techniques available for using enzymatic analysis, applications in medicine, industries, and biotechnological applications	8

TEXT BOOKS:

1. Trevor Palmer, “Understanding Enzymes”, 4th edn., Prentice Hall, 1991.

REFERENCE BOOKS:

1. Bailey J.E and Ollis, D.F, “Biochemical Engineering fundamentals”, McGraw Hill, 2005.
2. John R. Whitaker, Alphons G J Voragen, and DWS Wong, “Handbook of Food Enzymology”, Marcel Dekker, NewYork, 2003.

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M.TECH. IN BIOCHEMICAL ENGINEERING

BIOINSTRUMENTATION - 16CHBCPEBI

Subject Code	:	16CHBCPEBI	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1 Apply the theoreticalconcepts behind the functioninganalytical instrument

CO 2 Understand the impact, complexity of each instrument, itsinstruments based on appropriate criteria, analyses and interpret the experimental data using novel techniques

CO 3 Analyze the data from advance instruments for precise analysis of biomolecules.

Module 1	Hrs.
BASIC LABORATORY INSTRUMENTS: Principle and working of pH meter, Conductivity meter. **SPECTROSCOPY:** UV Spectroscopy, Principles, Instrumentation and applications. Spectroflourimetry; Principle, Stoke's shift, quantum efficiency, instrumentation and applications, Numerical on Spectroscopy	07
Module 2	
ELECTROPHORESIS: General principle, factors affecting electrophoresis – voltage, current, resistance, buffer– composition, concentration, pH. Gel electrophoresis: Types of gels: (starch, agarose, polyacrylamide), Idea of electrophoresis unit, preparation of gel, sample application, running the samples, SDS-PAGE - Principle, apparatus and methods, gradient gels, Two dimensional gels, isoelectric focusing. **MICROSCOPIC IDENTIFICATION OF VARIOUS MICROORGANISMS:**Phase contrast Microscopy, confocal microscopy Fluorescent Microscopy, Electron Microscopy, Scanning Ion Conductance Microscopy, Video Micrography, Atomic force Microscopy. Flow Cytometry.	08
Module 3	
CHROMATOGRAPHIC TECHNIQUES–I: Introduction to chromatography: General principles,column chromatography– columns, stationary phases. Packing of columns, application of sample, column development, fraction collection and analysis). Partition and adsorption chromatography (brief idea). **Affinity Chromatography:** Principle, materials matrix, selection of attachment of ligands, practical procedures, specific and non-specific elution, applications. **Ion Exchange Chromatography:** Principle, types of exchangers, materials, choice of exchangers and buffers and applications. **Gel Filtration chromatography:** Principle, idea of distribution coefficient, exclusion limit, fractionation range, bed volume, void volume, elution volume, chemical properties of gel and applications. Numerical	08
Module 4	
CHROMATOGRAPHIC TECHNIQUES II: **Gas Chromatography:** Principle of GC system, solid support, capillary column, stationary phase, preparation and application of sample, separation conditions, detection systems and applications. **High Performance Liquid Chromatography (HPLC):** Principle, components of HPLC	08

system, column, column packing, chromatographic solvents, pumping systems, detectors systems and its applications. Numerical on Chromatography.	
Module 5	
ATOMIC AND FLAME SPECTROPHOTOMETRY: Principles, Instrumentation and applications for flame emission / atomic absorption spectrophotometry and their comparative study. **MASS SPECTROMETRY:** Principles, Instrumentation and applications. Theory and applications of IR, NMR, Fluorescence, Atomic Absorption, Mass spectroscopy, CD, ORD, Mass, Raman Spectroscopy, ESR principles - instrumentation-applications, Beer-Lambert's law, Use of NMR in elucidation biosynthesis pathways.	08

TEXT BOOKS

1. Chatwal G R and Anand SK,"Instrumental Methods of Chemical Analysis", 5th edn., Himalaya Publishing House, New Delhi,2014.
2. Douglas A. Skoog, F. James Holler, Stanley R. Crouch., "Principles of Instrumental Analysis", 6th edn., Thomson Brooks,Cole, 2007.

REFERENCES:

1. Lloyd R. Snyder, Joseph J. Kirkland, John W. Dolan., "Introduction to Modern Liquid Chromatography", 3rd edn., Wiley- Blackwell, Scholarly Publishing, 2016
2. H.H. Willard, L.L. Merritt, J.N. Dean and F.A. Settle, "Instrumental methods of analysis", I.B.H. Publishing House, New Delhi, 2016.

BIOLOGICAL THERMODYNAMICS - 16CHBCPEBT

Subject Code	:	16CHBCPEBT	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1 Understand and apply the laws of thermodynamics to analyze energy flows in a biological system.
CO 2 Evaluate Gibbs free energy and calculate attainable work for engineering and biological system

Module 1	Hrs.
FRONTIER OF BIOLOGICAL THERMODYNAMICS: Energy conservation in living organism, Irreversibility and life, third law and biology, entropy and protein stability, Energy, information processing and life, second law and evolution, Gibbs free energy, Equilibrium concepts for biological thermodynamics.	7

Module 2	
FUNDAMENTAL CONCEPTS OF THERMODYNAMICS: System and Surroundings, First law of thermodynamics -Internal energy, enthalpy, Heat capacity, applied examples from biochemistry.	8
Module 3	
ENTROPY: Second law – Entropy and universe, Concept of heat engines, protein stability and calorimetric measurements.Fundamentals of Differential scanning calorimeter and Isothermal calorimeter in biological property measurements, Third law of thermodynamics, Maxwell equations, Gibbs-Duhem Equation and the Phase Rule, Legendre Transforms.	8
Module 4	
GIBBS FREE ENERGY AND ITS APPLICATIONS: Gibbs free energy and equilibrium, Chemical potential, ionic solutions, Equilibrium constant, standard state in biochemistry, Acid and bases, chemical coupling and redox reactions, Gibbs free energy in photosynthesis, glycolysis citric acid cycle, Oxidative phosphorylation and ATP hydrolysis, substrate cycling, Membrane transport, Enzyme substrate interaction, Haemoglobin, Protein solubility, stability and dynamics.	8
Module 5	
REACTION KINETICS: Rate of a reaction, rate constant and order of the reaction, effect of temperature, collision and transition state theory, Electron transfer kinetics, Enzyme kinetics and inhibition, Reaction mechanism of lysozyme, protein folding and pathological misfolding, polymerisation, muscle contraction and the molecular motors.	08

TEXT BOOK

1. Donald T. Haynie, “Biological Thermodynamics”, Cambridge press, 2008.
2. Robert A. Alberty, “Thermodynamics of Biochemical Reactions”, JohnWiley publications, 2003.

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SECOND SEMESTER M.TECH – BIOCHEMICAL ENGINEERING
STATISTICAL METHODS – 16CHBCPCSM

Subject Code	:	16CHBCPCSM	LTPS	:	3-1-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	04			

COURSE OUTCOMES:

CO1 Estimate the closeness of two variables and prediction of one variable from the other and to obtain the degree of relationship between two variables by performing regression analysis
CO2 Apply the basic principles of probability and probability distributions to the problems in Biochemical Engineering and to the field of genetics.
CO3 Demonstrate an understanding of sampling and its various techniques.
CO4 To draw inferences about the characteristics of population from the samples based on the parametric and non-parametric tests.
CO5 To conceive and conduct a designed experiment to characterize a process

Module 1	Hrs.
INTRODUCTION: Scope of biostatistics, definition, data collection, presentation of data, graphs, charts (scale diagram, histogram, frequency polygon, frequency curve, logarithmic curves). Sampling & selection bias, probability sampling, random sampling, sampling designs. Descriptive statistics: Measure of central tendency (arithmetic mean, geometric mean, harmonic mean, median, quartiles, mode); Measure of dispersion (range, quartile deviation, mean deviation and standard deviation, coefficient of variation).	09
Module 2	
BI-VARIATE DISTRIBUTION: Correlation and regression analysis (simple and linear) curve fitting (linear, non-linear and exponential). **PROBABILITY:** Axioms, models, conditional probability, Bayes rule, Genetic Applications of Probability, Hardy - Weinberg law, Wahlund's Principle, Forensic probability determination, Likelihood of paternity, Estimation of probabilities for multi-locus/multi-allele finger print systems.	09
Module 3	
PROBABILITY DISTRIBUTIONS: Discrete probability distributions - Binomial, Poisson, geometric – derivations. Central limit theorem. Continuous probability distribution – normal, exponential, gamma distributions, beta and Weibull distributions, T& F distributions.	07
Module 4	
STATISTICAL INFERENCE: Estimation theory and testing of hypothesis, point estimation, interval estimation, sample size determination, simultaneous confidence intervals, parametric and non-parametric distributions (T-test, F-test, Chi Squared distribution, goodness of fit test) analysis of variance (one-way and two-	07

way classifications). Case studies of statistical designs of biological experiments (RCBD, RBD).	
Module 5	
DESIGN OF EXPERIMENTS: Sample surveys, comparisons groups and randomization, random assignments, single and double blind experiments, blocking and extraneous variables, limitations of experiments. **CASE STUDIES:** Statistical tools for setting in process acceptance criteria; T-Test based approach for confirming human antibody response to therapeutic drug; Population statistics for cases related to cigarette smoking, Lung cancer, endangered plants species, epidemics etc.	07

TEXT BOOKS:

1. Sokal, R. R. and F. J. Rohlf, "Biometry: the principles and practice of statistics in biological research", 3rd edn.,W. H. Freeman and Co, New York, 1995.
2. Veer BalaRastogi, "Fundamentals of Biostatistics", Ane Books Pvt. Ltd., New Delhi, 2009.

BIOENERGY – 16CHBCPCBE

Subject Code	:	16CHBCPCBE	LTPS	:	3-0-0-1
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	04			

COURSE OUTCOMES:

CO 1. Understand the basic knowledge of biomass and its sources.
CO 2. Characterize the bioethanol and biodiesel production with its applications.
CO 3. Understand the biogas technology, pyrolysis and gasification of biomass.

Module 1	Hrs.
BIOENERGY RESOURCES: Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification. Chemical composition and properties of different biomass materials and bio-fuels, Structural properties, Physical properties, properties of microbial biomass, Biomass resource assessment. Energy plantations -Preparation of woody biomass: Size reduction, Briquetting of loose biomass, Drying, Storage and Handling of Biomass, hydrogen production and biological fuel cell.	09
Module 2	
ETHANOL: Biomass constituent to liquid fuels, liquid fuel alcohol from sugar cane molasses, sweet sorghum, and other sources like corn and lignocelluloses. Lignocelluloses ethanol production technologies, conversion. Corn ethanol production technologies, chemistry of ethanol fermentation, by products from fermentation process.	07
Module 3	
BIODIESEL: Definition and properties of biodiesel Properties of Biodiesel, Catalyst used for biodiesel production. Biofuels from vegetable oil: production of vegetable oil, composition, process of extraction of vegetable oil, applications. Trans-Esterification of Oils to produce Bio-Diesel. Biofuels from algae: Microalgae growth, algae harvesting, extraction and utilization of	09

liquid biofuels.	
Module 4	
BIOGAS TECHNOLOGY: Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, animal residues-. Microbial and biochemical aspects- Operating parameters for biogas production Kinetics and mechanism - Dry and wet fermentation. Digesters for rural application-High rate digesters for industrial waste water treatment.	08
Module 5	
PYROLYSIS AND GASIFICATION OF BIOMASS: Biomass conversion routes, biomass densification technologies, biomass combustion of woody biomass. Biomass pyrolysis, cogeneration in biomass Processing Industries. Guidelines for designing downdraft gasifiers. Pyrolysis of biomass-Pyrolysis regime, effect of particle size, temperature, and products obtained. Thermo-chemical gasification principles: Effect of pressure, temperature and of introducing steam and oxygen. Design and operation of Fixed and Fluidized Bed Gasifiers.	06

TEXT BOOK

1. Sunggyu Lee and Y T Shah, "Biofuels and Bioenergy- Process and Technology", CRC Press, 2014.
2. VV N Kishore, "Renewable energy engineering and technology –principles and practice", TERI Press, New Delhi, 2010.

REFERENCE BOOKS

1. Caye M. Drapcho, N.P. Nhuan and T. H. Walker, "Biofuels Engineering Process Technology" , McGraw Hill Publishers, New York, 2008.
2. Jonathan R.M., "Biofuels – Methods and Protocols (Methods in Molecular Biology Series)", Humana Press, New York, 2009.
3. Lisbeth Olsson,"Biofuels (Advances in Biochemical Engineering/Biotechnology Series", Springer-Verlag Publishers, Berlin, 2007.
4. G D Rai, "Nonconventional Energy Sources", 4th edn.,Khanna Publications, 2010.

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MTECH IN BIOCHEMICAL ENGINEERING

REACTION ENGINEERING – 16CHBCPCRE

Subject Code	:	16CHBCPCRE	LTPS	:	3-1-1-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	05			

COURSE OUTCOMES:

CO 1. Develop kinetic of heterogeneous reaction for catalytic and non – catalytic reaction using various models with and without consideration of effective mass and energy transport**.**

CO 2. Analyze the flow behavior, contacting, conversion and performance of non-ideal reactors using various models and comparison with ideal reactor.

CO 3. Applyknowledge ofreactionkinetic andflow behavior to design heterogeneous catalytic reactors for different reaction conditions.

Module 1	Hrs.
KINETICS OF HETEROGENEOUS REACTIONS: Catalytic Reactions, Rate controlling steps, Langmuir - Hinshelwood model, Rideal - Eiley Mechanism, Steady State approximation, Non catalytic fluid - solid reactions, Shrinking and unreacted core model.	09
Module 2	
POPULATION BALANCE MODELS: Mixing concepts, Residence Time Distribution, Response measurements, Segregated flow model, Dispersion model, Series of stirred tanks model, Recycle reactor model, Analysis of non-ideal reactors.	09
Module 3	
EXTERNAL DIFFUSION EFFECTS IN HETEROGENEOUS REACTIONS: Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, Modelling diffusion with and without reaction.	07
Module 4	
INTERNAL TRANSPORT PROCESSES IN POROUS CATALYSTS: Intra pellet mass and heat transfer, Evaluation of effectiveness factor, mass and heat transfer with reaction.	07
Module 5	
DESIGN OF HETEROGENEOUS CATALYTIC REACTORS: Isothermal and adiabatic fixed bed reactors, Non-isothermal and non-adiabatic fixed bed reactors. Two phase fluidized bed model, slurry reactor model and Trickle bed reactor model.	07

REACTION ENGINEERING LABORATORY

NOTE: ANY FIVE EXPERIMENTS

LIST OF EXPERIMENTS

1. Batch reactor
2. Isothermal continuous plug flow reactor
3. Continuous stirred tank reactor
4. Semi batch reactor
5. Packed bed reactor
6. Effect of temperature on rate of reaction
7. Effect of concentration on enzyme activity

8. Effect of Temperature on enzyme activity
9. RTD studies in tubular reactor
10. RTD studies in tank reactor

TEXT BOOKS:

1. Fogler H.S., "Elements of Chemical Reaction Engineering", Prentice Hall, 1991.
2. John Villadsen, Jens Nielsen, Gunnar Lidén, "Bioreaction Engineering Principles", Springer Science & Business Media, 2011.
3. Bischoff and Froment, "Chemical Reactor Design and Analysis", Addision Wesley, 1982.

REFERENCE BOOKS:

1. Levenspiel, O., "Chemical Reaction Engineering" , 3rd edn.,Wiley,2005.
2. Smith J.M, "Chemical Engineering Kinetics", 3rd edn.,McGraw-Hill,1984.

BIOLOGICAL WASTE TREATMENT AND ENGINEERING – 16CHBCPEBW

Subject Code	:	16CHBCPEBW	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1. Cognize the different regulatory standards with design criteria for environmental parameters
CO 2. Learn the wastewater treatment criteria based on the regional requirement.
CO 3. Comprehend the reaction kinetics, reactor selection and its process analysis.
CO 4. Design the treatment plant based on the fundamentals studies, bench scale and pilot plant studies.

Module 1	Hrs.
INTRODUCTION: Objectives of wastewater treatment. Flow measurements and Composition. Characterization -Properties and analysis of wastewater, Problems on wastewater characterizations. Waste-water treatability studies-a bench scale and pilot scale. Effluent standards for discharge to water bodies and land applications- state and central	08
Module 2	
PHYSICAL AND CHEMICAL TREATMENT OF WASTEWATER: Screens, Comminutes, Grit chambers, Flow equalizations, Sedimentation, Flotation, Granular medium filtration Chemical treatment: chemical precipitation, Adsorption, Disinfection with chlorine, ozone, Ultraviolet light etc. Treatment disposal of sludge – Sludge characteristics, concentration. Aerobic/Anaerobic sludge digestion, sludge conditioning, Dewatering and drying. Incineration and wet oxidation.	09
Module 3	
MICROBIOLOGY OF WASTE TREATMENT: Growth and inhibition of bacteria. Kinetic of Biological growth, Batch culture substrate limited growth, Cell growth and substrate utilization, Effects of endogenous metabolism. Monods and Michaels Menton kinetics and their applications. Determination of kinetic coefficients. Fundamentals of process analysis, Mass balance analysis,	09

Reactors and their hydraulic characteristics, Reaction kinetics and Reactor selection. (Batch, Plug flow, Completely stirred tank reactor and packed and fluidized bed reactor).	
Module 4	
BIOLOGICAL TREATMENT PROCESSES: Aerobic/Anaerobic attached and suspended growth treatment processes- Activated sludge process: Process analysis : Completely mix with recycle, Sequential Batch Reactor (SBR), Rotating biological contactor/disc (RBC), Trickling filter, UASB digester, aerated lagoon, stabilization ponds.– Standard type and modifications. Aerators/diffusers. With applicable numerical	06
Module 5	
BIOLOGICAL NUTRIENT REMOVAL: Nitrogen removal with and without phosphorous removal, Nitrogen and Phosphorous removal, Phosphorous removal with or without nitrifications, Removal of ammonia by biological nitrifications, Removal of Nitrogen by biological nitrification/denitrifications. Combined removal of Nitrogen and Phosphorus by Biological, Physical and Chemical methods.	07

TEXT BOOKS:

1. Eckenfelder and O'Conner, "Biological Waste Treatment",Pergamon Press, 2001.
2. Metcalf and Eddy, "Wastewater Engineering -Treatment, Disposal & Reuse", Tata McGraw Hill, 1991.

REFERENCE BOOKS:

1. H.E. Babbilt and R.Baumann, "Sewage and Sewage Treatment", 1986.
2. RonandDroste, "Theory and practice of water and wastewater treatment", John Wiley and sons, Canada, 2005.
3. George Tchobanoglous and Franlin L. Burton, "Wastewater Engineering- Treatment, Disposal and Reuse", Tata McGraw Hill Publishing Co. Ltd, 1990.

BIOPROCESS MODELINGAND SIMULATION - 16CHBCPEBM

Subject Code	:	16CHBCPEBW	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1. Understand the modeling concepts and illustrate examples of a model
CO 2. Apply and model Heat and mass transfer problems
CO 3. Understand chemical-biochemical reaction kinetics and model reactors.
CO 4. Understand the kinetic modeling for biosensor applications.
CO 5. Implement nonlinear dynamic concept in bioprocess modeling.

Module 1	Hrs.
INTRODUCTION TO PROCESS MODELING: Models and model building, model formulation principles. Fundamental laws used in modeling: Continuity Equation, Energy Equation, Equation of motion and transport Equations-equations of state &equilibrium states. Classification of mathematical models: linear & non-linear models, static & dynamic models and	07

lumped & distributed parameter models, with examples for all the models.	
Module- -2	
MODELS FOR HEAT AND MASS TRANSFER EQUIPMENTS: Heat loss through maturing tank, counter current cooling tanks, heat transfer through extended surfaces, multiple distillation columns, multistage gas absorption, Numericals.	08
Module- -3	
MODELS IN REACTION ENGINEERING: Unstructured growth model with bottle-neck kinetics, Adiabatic batch reactor: Assumptions, model development, continuous stirred tank bioreactor, fed batch bioreactor, **pH-dependent bioprocess**- Enzymatic conversions; state and parameter estimation in bioreactors, Numerical.	09
Module- -4	
KINETIC MODELING FOR BIOSENSORS: The purpose and practice of modeling; The flux equations, The flux diagram for the membrane/enzyme/electrode, Deriving a complete kinetic model; Kinetic modeling in other types of biosensors- Potentiometric enzyme electrodes, Optical and photometric biosensors.	09
Module 5	
NONLINEAR DYNAMICS: A simple population growth model. More complex growth models, chaotic behavior, cob web diagrams, stability of fixed point solutions. Introduction to bifurcations behavior for single and two variable systems, introduction to chaos and the Lorenz equations.	08

TEXT BOOK

1. William. L Luyben, "Process Modeling Simulation and Control for Chemical Engineering, 2nd edn.,McGraw Hill", 1990.
2. B.V.Babu, "Process plant simulation", OXFORD university publication press, 2012.
3. Wayne Bequette.B., "Process dynamics modeling and analysis and simulation", Prentice Hall Inc., 2004.

REFRENCE BOOKS

1. Turner A.P.F, Karube.I,Wilson,G.S., "Biosensors Fundamentals and applications", Oxford Univ. Press, 1990.
2. John H. Seinfeld, Leon Lapidus., "Mathematical Methods in Chemical Engg. Process Modeling, Estimations and Identification", Prentice Hall, 1974.

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MEMBRANE SEPARATION TECHNOLOGY- 16CHBCPEMS

Subject Code	:	16CHBCPEMS	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1: Classify and characterizer the membranes for bio separation.
CO 2: Understand the preparation of membranes
CO 3: Analyze and select the appropriate method of membrane and membrane process.
CO 4: Evaluate the flux of solvent and solute through membrane.

Module 1	Hrs.
INTRODUCTION: Membrane separation process, Definition of Membrane, Membrane types, Advantages and limitations of membrane technology compared to other separation processes, Membrane materials and properties. Membrane Modules	07
Module 2	
CHARACTERIZATION OF MEMBRANES Preparation of synthetic membranes: Phase inversion membranes, Preparation techniques for immersion precipitation, Synthesis of asymmetric and composite membranes and Synthesis of inorganic membranes.	09
Module 3	
TRANSPORT IN MEMBRANES: Introduction, Driving forces, Non-equilibrium thermodynamics, Transport through porous membranes, transport through non-porous membranes, Transport through ion-exchange membranes. Pressure driven membrane processes, Concentration as driving force, Electrically driven membrane processes, Numericals on transport of solute/solvent in membrane Separations	07
Module 4	
MEMBRANE PROCESSES: Reverse osmosis, electro dialysis, gas permeation; pervaporation, concentration, pressure, electrically and thermally driven membrane processes; membrane bioreactors, liquid membranes **MAJOR AREAS OF APPLICATIONS:** Chemical industry, pharmaceutical industry, Food Industry, and Biotechnology industries	09
Module 5	
LIMITATIONS OF MEMBRANES: Polarisation phenomena and fouling: Concentration polarization, Pressure drop, Membrane fouling, methods to reduce fouling. Factors affecting retentivity, concentration polarization, gel polarization, fouling, cleaning and regeneration of membranes.	07

TEXT BOOK

1. Nath K., "Membrane Separation Processes", Prentice-Hall Publications, New Delhi, 2008.

REFERENCE BOOKS

1. Marcel Mulder, "Basic principles of Membrane Technology", Kluwer Academic Publishers, Boston,

London.

2. Baker R. W., "Membrane Technology and Research", Inc.(MTR), Newark, California, USA, 2004.
3. J.D.Seader, Ernest J. Henley, D. Keith Roper, "Separation Process Principles:Chemical and Biochemical Operations", 3rdedn., Wiley 2010.
4. Geankoplis C. J., "Transport Processes And Separation Process principles" 4thedn., Prentice-Hall of India Private Ltd , New Delhi.

ANIMAL & TISSUE CULTURE ENGINEERING 16CHBCPEAT

Subject Code	:	16CHBCPEAT	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1. Understand the characteristics of animal cells hybridoma technology in scale up and large scale operation
CO 2. Prepare, sterilize and harvest the tissue, organ and organotypic culture media using advanced techniques
CO 3. Know on tissues like skin, bone, tendon and national and international regulations of pharmaceutical and medical tissue products

Module 1	Hrs.
Characteristics of animal cell, metabolism, regulation and nutritional requirement. Effects of shear force and kinetics of cell growth and product formation. Product and substrate transportation	07
Module 2	
Hybridoma technology; genetic engineering in animal cell culture; scale-up and large scale operation; Perfusion bioreactors, hollow fiber bioreactor, operational strategies of mass cell culture.	07
Module 3	
Disaggregation (enzymatic and mechanical) of tissue and primary culture; Cultured cells and evolution of cell lines; Maintenance of cultures – cell lines; Cloning of cell lines; Large scale cell cultures in biotechnology ; Somatic cell fusion	09
Module 4	
Culture media (Preparation and sterilization), Harvesting, selection and expansion. Differentiation, Change of phenotype. Cryopreservation. Tissue, organ and organotypic cultures. Mass transport and nutrition gradients in tissue engineering (O_2) as model. Cryopreservation of organs and ECM-Freezing and vitrification. Most common Bioreactors in Tissue Engineering, Cell Seeding in Bioreactors, Bioreactor Applications in Functional Tissues, Design Considerations, Challenges in Bioreactor Technologies.	09
Module 5	
Tissue Engineering of Skin, Bone, tendon, Adipose Tissue Engineering Introduction, FDA	07

Regulation, Regulation of Pharmaceutical / Medical Human Tissue Products in Europe/USA, Other considerations Relevant to Engineered Tissues.	

TEXT BOOKS

1. Clemens Van Blitterswijk, "Tissue Engineering", Academic Press; 2 Edition, 2014
2. John P. Fisher, A G Mikos& Joseph D. Bronzino, "Tissue Engineering", CRC Press, 2007.

REFERENCE BOOKS

1. Anthony Atala& P Lanza, "Methods of Tissue Engineering", Academic Press Elsevier, 2006.
2. Robert Lanza, Robert Langer and Joseph P. Vacanti, Principles of Tissue Engineering, 2013 (ISBN: 978-0-12-398358-9)

NANOTECHNOLOGY IN BIOPROCESS INDUSTRIES – 16CHBCPENT

Subject Code	:	16CHBCPENT	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO1. Learn basic knowledge in the interface between chemistry, physics and biology on the nano structural level with a focus on bioprocess industries use
CO2. Understand Basic concepts of BioMEMS and their use in drug delivery
CO3. Know the available nanomaterials in biological system

Module 1	Hrs.
METHODS OF MEASURING PROPERTIES: Atomic size, crystallography, Particle size determination, Surface structure, Microscopy- Transmission Electron Microscopy, Field Ion Microscopy, Scanning Microscopy; Spectroscopy- Infrared and Raman Spectroscopy, Photoemission and X-ray Spectroscopy, Magnetic resonance.	07
Module 2	
PROPERTIES OF INDIVIDUAL NANOPARTICLES: Metal nanoclusters, Semiconducting nanoparticles, Rare gas and molecular clusters, methods of synthesis- RF Plasma, Chemical Methods, Thermolysis, Pulsed Laser methods. Carbon nanostructures: Carbonmolecule, Clusters, Carbon nanotubes, Applications. Bulk nanostructured materials: Solid disordered nanostructures, nanostructure crystals	07
Module 3	
NANOSTRUCTURED FERROMAGNETISM: Basics of ferromagnetism, Effect of bulk nanostructuring of magnetic properties, dynamics of nanomagnets. nanostrucures in zeolite cage. Quantum wells, wires and dots: Preparation of quantum nanostructures, Single electron tunneling, Applications. Catalysis: Nature of catalysis, Surface area of nanoparticles, porous materials, pillered clays, Colloids.	09
Module 4	
BIOMEMS: Introduction and Overview, BioMEMS Applications: Case Studies in	09

BiomagneticSensors, Applications of optical and chemical transducers. Ultimate Limits of Fabrication and Measurement, Recent Developments in BioMEMS. Drug Delivery using Nanobiosensors, Drug Delivery Applications, Bioavailability, Suistained and targeted release, Drug Delivery, Health Risks, and Challenges**.**	
Module 5	
BIOLOGICAL NANOMATERIALS: Biological building blocks, biological nanostructures. Nanomachines and nanodevices: Microelectromechanical systems (MEMSs), Nanoelectromechanical Systems (NEMSs) - Fabrication, Devices. Molecular and Supramolecular Switches. Nanodiagnostics: Diagnostics and Sensors, Rapid *Ex-Vivo* Diagnostics, Nanosensors as Diagnostics, Nanotherapeutics. Nanofabricated devices to separate and interrogate DNA, Interrogation of immune and neuronal cell activities through micro- and nanotechnology based tools and devices.	07

TEXT BOOK:

1. Charles P. Poole, Jr., Frank J. Owens, "Introduction to Nanotechnology", John Wiley and Sons, 2009.
2. HariNalwa,"Handbook of Nanostructured Materials and Nanotechnology", Academic Press, Boston, 2000.

REFERENCE BOOK

1. C. N. R.Rao, "Nanoworld- An introduction to science and technology", JNCASR, Bangalore, 2010.

BIOSENSORS - 16CHBCPEBS

Subject Code	:	16CHBCPEBS	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO1. Acquaint with definition need of biosensor types of sensors viz., optical sensors, electrochemical sensors, thermal sensors and mass sensors and their parameters.
CO2. Learn role of transducers in chemical analytics during the work with biosensors.
CO3. Practice the kinetic modeling of biosensors and learn the applications in industrial online monitoring

Module 1	Hrs.
INTRODUCTION:A historical perspective; Definition and Expanding Needs of Biosensors; Advantages and limitations; Biosensor Economics; various components of biosensors	07
Module 2	
TYPES OF BIOSENSORS: Biocatalysts based biosensors, bio affinity based biosensors & microorganisms based biosensors, biologically active material and analyte. Types of membranes used in biosensor constructions	07
Module 3	
TRANSDUCERS IN BIOSENSORS: Various types of transducers; principles and applications; Bio-, chemi-, and electrochemiluminescence for fiber-optic biosensors; Fluorescence-based fiber-	09

optic biosensors	
Module 4	
KINETIC MODELING FOR BIOSENSORS: The purpose and practice of modeling; The flux equations, The flux diagram for the membrane/enzyme/electrode, Deriving a complete kinetic model; Kinetic modeling in other types of biosensors- Potentiometric enzyme electrodes, Optical and photometric biosensors, Immunosensors	09
Module 5	
APPLICATION AND USES OF BIOSENSORS: Biosensors in medicine and health care, biosensors for agriculture and food; Low cost- biosensor for industrial processes for online monitoring; biosensors for environmental monitoring.	07

TEXT BOOKS:

1. Rajmohan Joshi, "Biosensors ", Gyan Books, 2006.
2. Cooper J.M. and Anthony E.G, "Biosensors", 2nd edn.,Oxford University Press, 2004.
3. Turner A.P.F, Karube.I, Wilson,G.S, "Biosensors Fundamentals and applications", Oxford Univ. Press, 1990.
4. SadanaA., "Biosensors: Kinetics of Binding and Dissociation Using Fractals", Elsevier B.V, 1995.

REFERENCE BOOKS

1. Ashok M and Kim Rogers, "Enzyme & Microbial Biosensors: Techniques and Protocols (Methods in Biotechnology)", Humana Press, 1998.
2. DamiaBarcelo, "Biosensors for the Environmental Monitoring of Aquatic Systems: Bioanalytical and Chemical Methods for Endocrine Disruptors", Springer, 2009.

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SAFETY MANAGEMENT IN BIOPROCESS INDUSTRIES - 16CHBCPESM

Subject Code	:	16CHBCPESM	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1. Understand the biohazard and its abatement in a safe way.
CO 2. Risk analysis, assessment and abatement of hazards for the safe operation of processes in biochemical industries.
CO 3. Apprehend process safety in Biotechnological based products in order to comply with industrial & regulatory standards

Module 1	Hrs.
BIOTECHNOLOGY AND SOCIETY: Introduction to science, technology and society, biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries.	07
Module 2	
BIO-SAFETY CONCEPTS AND ISSUES: Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards, biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. The Cartagena protocol on biosafety. Biosafety management: Key to the environmentally responsible use of biotechnology. Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons	07
Module 3	
BIO-SAFETY IN THE LABORATORY: Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution.	09
Module 4	
REGULATIONS: Good manufacturing practice and Good lab practices (GMP and GLP). GMOs: Concerns and Challenges, Regulatory mechanism for GMO, Case studies in IPR (Turmeric and Neem Patent Case) and Biosafety (BtBringal and Bt cotton, Golden Rice)	07
Module 5	
FOOD SAFETY: The GM-food debate and biosafety assessment procedures for biotech foods & related products, case studies of relevance. Environmental aspects of biotech applications. **AGRI AND PHARMA SECTOR:** Plant breeder's rights. Legal implications, Biodiversity and farmers rights. Recombinant organisms and transgenic crops, case studies of relevance. Biosafety assessment of pharmaceutical products such as drugs/vaccines etc. Biosafety issues in Clinical Trials.	09

TEXT BOOK

1. DeepaGoel&ShominiPrasar, IPR, "Biosafety, and Bioethics", Pearson Press, New Delhi 2013.

2. Thomas J. A., Fuch R. I.,"Biotechnology and safety assessmen", Academic press 2002.

REFERENCE

1. Fleming D. A., Hunt D. L., "Biological Safety principles and practices", ASM Press, 2000.
2. Lees F.P, "Loss Prevention in Process Industries", 2nd edn., Butterworth Heinemann, 1996.
3. Patterson D., "Techniques of safety managements", McGraw Hill, 1978.
4. Handley W., "Industrial Safety hand book", 2nd edn., McGraw Hill, 1977.
5. Levine S.P. Martin, "Protecting personnel at hazardous waste sites", Butterworth, 1985.

BIOPHARMACEUTICALS- 16CHBCPEBP

Subject Code	:	16CHBCPEBP	LTPS	:	3-0-0-0
No of Lecture Hrs/Week	:	03	Exam hours	:	03
Total No.of Lecture Hours	:	39	CIE +SEE Exam Marks	:	50+50=100
Credits	:	03			

COURSE OUTCOMES:

CO 1. Reinforce the knowledge on biopharmaceuticals, distinguish it from chemical drugs and identify the pharmaceuticals of plant, animal and microbial origin.
CO 2. Analyze the sources of biopharmaceuticals and to identity the products of biopharmaceuticals for various applications.
CO 3. Design the biopharmaceutical manufacturing process with consideration of clean room, maintaining records and study the products using appropriate characterization technique.
CO 4. To design a suitable drug delivery process and inculcate critical thinking to perform clinical trials in order to meet the required regulations.
CO 5. To develop research skills for identification structure activity relationship of drugs, and hence to design advanced drug delivery systems.

Module 1	Hrs.
BIOPHARMACEUTICALS: AN OVERVIEW: History of biopharmaceutical industry, Birth and age of biopharmaceuticals, Biopharmaceuticals: current status and future prospects, Distinctions between Chemical Drugs Versus Biopharmaceuticals ,Traditional pharmaceuticals of biological origin, Pharmaceuticals of animal, plant and microbial origin	07
Module 2	
SOURCES OF BIOPHARMACEUTICALS: E. coli as a source of recombinant, therapeutic proteins, Expression of recombinant proteins in animal cell culture systems, Additional production systems: yeasts, Fungal production systems, Transgenic animals, Transgenic plants, Insect cell-based systems **PRODUCTS OF BIOPHARMACEUTICALS:** Cytokines, enzymes, hormones, clotting factors, vaccines, monoclonal antibodies, cell therapies, antisense drugs, and peptide therapeutics.	07
Module 3	

BIOPHARMACEUTICAL MANUFACTURING: Clean rooms, Water for biopharmaceutical processing, Generation of purified water and water for injections (WFI), Documentation and Specifications, Manufacturing formulae, processing and packaging instructions, Generation of manufacturing records **PRODUCTION AND ANALYSIS OF FINAL PRODUCT**: Cell banking systems, Upstream processing, Microbial cell fermentation, Mammalian cell culture systems, Downstream processing, Final product formulation. Product potency, Determination of protein concentration, Detection of protein-based product impurities, Capillary electrophoresis, High-pressure liquid chromatography (HPLC), Mass spectrometry, Immunological approaches to detection of contaminants.	09
Module 4	
DELIVERY OF BIOPHARMACEUTICALS: Oral delivery systems, Pulmonary delivery, Nasal, Transmucosal and transdermal delivery systems. **CLINICAL TRIALS**: Pharmacokinetics and pharmacodynamics, Toxicity studies, Reproductive toxicity, teratogenicity, Mutagenicity, carcinogenicity and other tests, Clinical trial design, Trial size and study population, the role and remit of regulatory authorities for The Food and Drug Administration and new drug application	09
Module 5	
ADVANCED DRUG DELIVERY AND DESIGN: Introduction, Drug Therapeutic Index and Clinical Impact, Routes of Therapeutic Protein Administration, Approaches Using Devices, Physiological and Mechanistic Approaches, Molecular Approaches to design - Computer-Aided Drug Design, ligand structure based drug design, Quantitative Structure Activity Relationship (QSAR)	07

BOOKS:

1. Gary Walsh, "Biopharmaceuticals Biochemistry and Biotechnology", 2nd edn., John Wiley & Sons, Ltd., 2003.
2. Susanna Wu-Pong ,Yon Rojanasakul, "Biopharmaceutical Drug Design and Development",Humana Press, 2008.

REFERENCE BOOKS

1. Gary Walsh and Brendan Murphy, "Biopharmaceuticals, An Industrial Perspective", Kluwer Academic Publishers, 1999.
2. Shargel, L., Yu, A.B.C., "Applied Bio pharmaceutics and Pharmacokinetics", 5th edn.,McGrawHill, New York, 2005.
3. JörgKnäblein, "Modern Biopharmaceuticals, Recent success stories", Wiley-VCH Verlag GmbH & Co, Weinheim, Germany, 2013.
4. Gary Walsh, "Pharmaceutical Biotechnology Concepts and Applications", John Wiley & Sons Ltd., 2007.
5. O. Kayser, R.H. Muller, "Pharmaceutical Biotechnology, Drug Discovery and Clinical Applications", Wiley-VCH Verlag GmbH & Co. 2004.

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TECHNICAL SEMINAR - 16CHBCPCT1

Subject Code	:	16CHBCPCT1	LTPS	:	0-0-2-0
No of Lecture Hrs/Week	:	00	Exam hours	:	03
Total No.of Lecture Hours	:	00	CIE +SEE Exam Marks	:	50+50=100
Credits	:	2			

COURSE OUTCOMES	
CO1	To learn to carry out literature survey for the presentation
CO2	Communicate & report through technical presentations
CO3	Understand the need of bio-engineering solutions for sustainability and environmental conservation

The students are required to give a presentation on any topic in related field in the form of seminar. The seminar shall be evaluated as internal assessment by a committee constituted by the HoD

INSTITUTE CORE
RESEARCH METHODOLOGY - 16APRDICRM

Subject Code	:	16APRDICRM	LTPS	:	2-0-0-0
No of Lecture Hrs/Week	:	02	Exam hours	:	03
Total No.of Lecture Hours	:	26	CIE +SEE Exam Marks	:	50+50=100
Credits	:	02			

Module 1

Meaning, Objectives and Characteristics of research - Research methods Vs Methodology - Types of research - Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical - Research process - Criteria of good research - Developing a research plan

Module 2

Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem - Importance of literature review in defining a problem- **S**urvey of literature - Primary and secondary sources - Reviews, treatise, monographs patents - web as a source - searching the web - Identifying gap areas from literature review - Development of working hypothesis.

Module 3

IPRs- Invention and Creativity- Intellectual Property-Importance and Protection of Intellectual

Property Rights (IPRs)- A brief summary of: Patents, Copyrights, Trademarks, Industrial Designs- Integrated Circuits-Geographical Indications-Establishment of WIPO-Application and Procedures.

Module 4

Aim of this part of the course: is to strengthen students minds towards high quality research through publications, patents and also to learn research ethics. Publications (8-9 hours).Research concepts (2 hour) Research importance on economy, Research in India and abroad, Importance of publications, Why, where, when to publish? Publication ethics (2 hour), Plagiarism (how to use turn it in effectively), International ethics on research, What and what not to publish, Ethical guidelines, Case studies Quality vsquantity (2 hour) Searching literature with high quality, Impact factor, Citations (google scholar vs web of science), H-index, Case studies
How to write paper (2 hour), In High quality journals, Conference Articles, Poster preparation, PhD thesis, Inclusion of References Journal reviewing process (1 hour), Selection of the good journal, Knowledge bout journal template, Refereeing process, Research topic selection, Research today and tomorrow, Lab scale to Industry, Traditional research to Technology based research

Module 5

Self study: Interpretation and report writing - Techniques of interpretation - Structure and components of scientific reports - Different steps in the preparation - Layout, structure and language of the report - Illustrations and tables - Types of report - Technical reports and thesis

REFERENCES:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., New Delhi
4. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications. 2 volumes.
5. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
6. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
7. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper Sage Publications
8. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
9. Intellectual Property Rights in the Global Economy: Keith Eugene Maskus, Institute for International Economics, Washington, DC, 2000
10. Subbarau NR-Handbook on Intellectual Property Law and Practice-S Viswanathan Printers and Publishing Private Limited.1998

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INSTITUTIONAL ELECTIVE

FERMENTATION TECHNOLOGY - 16CHBCIEFT

Subject Code	:	16CHBCIEFT	LTPS	:	4-0-0-0
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	CIE +SEE Exam Marks	:	50+50=100
Credits	:	04			

COURSE OUTCOMES:
CO1. To devise the isolation and improvement methods base on metabolic pathway of the product
CO2. Design, formulate and sterilize the media for different inocula on large scale
CO3. To understand design and operation of basic control loops with respect to fermentation process

Module 1	Hrs.
INTRODUCTION TO FERMENTATION PROCESSES: The range of fermentation Processes: Microbial Biomass, Enzymes, Metabolites and Transformation Processes; Development of fermentation Industry; Components of Fermentation Process; **Microbial Growth Kinetics – A Review:** Batch Culture; Continuous Culture; Fed-batch Culture; Applications.	09
Module 2	
ISOLATION, PRESERVATION AND IMPROVEMENT OF INDUSTRIAL MICROORGANISMS: Isolation Methods utilizing the selection of desired characteristics; Isolation Methods not utilizing the selection of desired characteristics; Preservation Methods: At Low temperature, Dehydration, and their quality control; The selection and Isolation of induced mutants improving yields of secondary metabolites; Use of recombinant systems for the improvement of industrial microorganisms.	12
Module 3	
MEDIA FOR INDUSTRIAL FERMENTATIONS: Typical Media and formulation; Sources of Energy, Carbon, Nitrogen, Minerals, vitamins, precursors, Oxygen and others. **Sterilization of Media:** Medium Sterilization; Design of Batch and Continuous Sterilization; Sterilization of Fermenter, Feed, Air; Filtration of Air and Design of Filters**; Development of Inocula For Industrial Fermentations:** The development of Inocula for yeast, bacterial, fungal and streptomycete processes; Aseptic inoculation of plant Fermenters	09
Module 4	
INSTRUMENTATION AND CONTROL: Control Systems: Manual, automatic and their combination; Methods of measurement of for Process Variables: Temperature, Flow of gases and liquids, Pressure, Safety valves, Shaft Power, Rate of stirring, Foam, Weight, DO, Exit gas, pH, Redox etc.; On-line analysis of other chemical	12

factors; Application of computers in fermentation industry.	
Module 5	
RECOVERY AND PURIFICATION OF FERMENTATION PRODUCTS: A REVIEW: Filtration, Centrifugation, Cell Disruption, Extraction, Chromatography, Ultra filtration, Drying, Crystallization and Whole broth processing; **Effluent Treatment:** Strength of fermentation effluents; Disposal Methods; Treatment processes: Aerobic and Anaerobic; Byproducts;	10

TEXT BOOK

1. Peter F. Stanbury, Alan Whitaker and Hope, "Principles of Fermentation Technology", Pergamon Press, 2nd edn., Reprint 2010

REFERENCE BOOKS:

1. Shuler M. L. and Kargi F, "Bioprocess Engineering", 2nd edn., Prentice Hall, 2002.
2. Mitchell DA. Krieger N, Berovic, "Solid State Fermentation Bioreactors", Springer Press, Germany, 2005.

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BIOMATERIALS- 16BCHBCIEBM

Subject Code	:	16BCHBCIEBM	LTPS	:	4-0-0-0
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	CIE +SEE Exam Marks	:	50+50=100
Credits	:	04			

COURSE OUTCOMES:

CO 1: Classify and understand the properties of biomaterials
CO 2: Understand the concept of biocompatibility
CO 3: Ability to characterize the biomaterials using modern tools & techniques
CO 4: Assess biocompatibility of materials using in vivo and in vitro techniques
CO 5: Understand the concepts for developing new biomaterials for its applications.

Module 1	Hrs.
INTRODUCTION: Overview of Biomaterials, Impact of Biomaterials, Safety and efficacy Testing, Biocompatibility. Structure and properties of materials, Mechanical Properties of materials, thermal treatments	09
Module 2	
INTERACTIONS OF MATERIALS AND ITS CHARACTERIZATION: Interactions of materials with human body, bio-compatibility of materials, metals, alloys, ceramics, polymers and composites as biomaterials. *Characterization of Biomaterials:* Contact Angle, Infrared Spectroscopy, XRay Photoelectron Spectroscopy, Atomic Force Microscopy, X-Ray Diffraction,.	12
Module 3	
BIOPOLYMERS: Biopolymers, Collagen, Elastin, Silk, Chitosan, Cellulose, Alginate, material for drug delivery: biodegradable polymers. Applications of Biomaterial. **Hydrogels:** Synthesis and Properties of Hydrogels, Aplications of Hydrogels	09
Module 4	
APPLICATIONS OF BIOMATERIALS: Materials for hard tissue replacement: orthopaedic implants, dental implants. Materials for soft tissue replacement: dermal and facial prosthesis, cardiovascular implants, ophthalmology, materials for artificial organs transplant and extracorporeal device.	12
Module 5	
NEW TRENDS IN BIOMATERIALS: Recent developments in biomaterials, legal issues related to development of biomaterials, Role of Nano-biomaterials and its various application	10

TEXT BOOK

1. Sujatha V. Bhat, "Biomaterials, 2nd Edition", Narosa Publishing House, Mumbai, 2010.
2. Joon Park, R. S. Lakes, "Biomaterials: An Introduction", 3rd edn., Springer Press, 2009.

REFERENCES

1. Buddy D. Ratner, Biomaterials Science: An Introduction to Materials in Medicine 2nd edn., Academic Press, 2004.
2. H. Reza Rezaie, L. Bakhtiari, A. Öchsner, "Biomaterials and their Applications", Springer 2015.
3. C. MauliAgrawal, Joo L. Ong, "Introduction to Biomaterials: Basic Theory with Engineering Applications", Cambridge Texts in Biomedical Engineering Cambridge University Press, 2016.

BMS COLLEGE OF ENGINEERING, BENGALURU-19
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016-2017
MTECH IN BIOCHEMICAL ENGINEERING

THIRD SEMESTER M.TECH – BIOCHEMICAL ENGINEERING

INTERNSHIP/INDUSTRIAL TRAINING, REPORT AND VIVA-VOCE- 16CHBCPCIN

Subject Code	:	**16CHBCPCIN**	LTPS	:	0-0-0-0
No of Lecture Hrs/Week	:	00	Exam hours	:	03
Total No.of Lecture Hours	:	00	CIE +SEE Exam Marks	:	50+50=100
Credits	:	21			

COURSE OUTCOMES	
CO1	Communicate & report the industrial practices through technical presentations
CO2	Develop inter personal relationship and work as a member in diversified areas
CO3	Understand the essence and need of industrial safety & professional ethics
CO4	Understand the role of economics and management principles in the success of industrial operation

The student shall make a internship report of the activities undertaken during the first 8 weeks of internship to a panel comprising **Internship** Guide, a senior faculty from the department and Head of the Department.

- The College shall facilitate and monitor the student internship program.
- The internship report of each student shall be submitted to the University.
- The internship should be between the III Semester and IV Semester after availing a vacation of 2 weeks**.**
- The students are required to give a presentation on any INTERNSHIP in the form of seminar. The seminar shall be evaluated.

BMS COLLEGE OF ENGINEERING, BENGALURU-19

CHOICE BASED CREDIT SYSTEM (CBCS)

SCHEME OF TEACHING AND EXAMINATION 2016-2017

MTECH IN BIOCHEMICAL ENGINEERING

PROJECT PHASE I - 16CHBCPCP1

Subject Code	:	16CHBCPCP1	LTPS	:	0-0-0-0
No of Lecture Hrs/Week	:	00	Exam hours	:	03
Total No.of Lecture Hours	:	00	CIE +SEE Exam Marks	:	50+50=100
Credits	:	04			

COURSE OUTCOMES	
CO1	Perform extensive literature survey to understand the progress in the technological trends
CO2	Identify a feasible method to carry out the project work by considering professional ethics of engineering practice
CO3	To formulate one or more methodological approach to carry out the experiments to find a feasible solution for societal and environmental problems.
CO4	Communicate and present/publish effectively the methodological planned to carry out the project work.

Each student will be assigned an experimental, design, a case study or an analytical problem, to be carried out under the supervision of an internal guide. It should be relevant to the field and preferably of current research. The project work should be assigned at the beginning of the third semester. The project work should be completed at the end of the fourth semester. The project work shall be evaluated as an external examination by the committee constituted by the HOD.

BMS COLLEGE OF ENGINEERING, BENGALURU-19
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016-2017
MTECH IN BIOCHEMICAL ENGINEERING

FOURTH SEMESTER
M.TECH – BIOCHEMICAL ENGINEERING
PROJECT PHASE II, III AND FINAL EVALUATION - 16CHBCPCP2

Subject Code	:	16CHBCPCP2	LTPS	:	0-0-0-0
No of Lecture Hrs/Week	:	00	Exam hours	:	03
Total No.of Lecture Hours	:	00	CIE +SEE Exam Marks	:	100+100=200
Credits	:	23			

COURSE OUTCOMES	
CO1	Design and carry out the experiments/design/theoretical design/simulations work in team in the predetermined methodology.
CO2	Analyze and interpret the obtained data for optimum solution using suitable Engineering and IT tools.
CO3	Elucidate the short comings and identify the scope for future work
CO4	Communicate effectively the project the results/write effective reports to publicize the deduce solutions.
CO5	Understand the essence and need of professional ethics during project documentation

Each student will be assigned an experimental, design, a case study or an analytical problem, to be carried out under the supervision of an internal guide. It should be relevant to the field and preferably of current research. The project work should be assigned at the beginning of the third semester. The project work should be completed at the end of the fourth semester. The project work shall be evaluated as an external examination by the committee constituted by the HOD

TECHNICAL SEMINAR - 16CHBCPCT2

Subject Code	:	16CHBC4TS2	LTPS	:	0-0-2-0
No of Lecture Hrs/Week	:	00	Exam hours	:	03
Total No.of Lecture Hours	:	00	CIE +SEE Exam Marks	:	50+50=100
Credits	:	2			

COURSE OUTCOMES	
CO1	Communicate & report through technical presentations
CO2	Understand the need of engineering solutions for sustainability and environmental conservation
CO3	Understand the essence and need of professional ethics

The students are required to give a presentation on any topic in related field in the form of seminar. The seminar shall be evaluated as internal assessment by a committee constituted by the HoD.