VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME & SYLABUS OF TEACHING & EXAMINATION 2016-2017
M.TECH. BIOCHEMICAL ENGINEERING

I SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credit
			Theory	Practical/ Field Work/ Assignment	Duration	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16BCE11	Statistical Methods	4	-	3	20	80	100	4
2	16BCE12	Process Automation	4	-	3	20	80	100	4
3	16BCE13	Bioprocess Engineering	4	-	3	20	80	100	4
4	16BCE14	Bioreactors	4	-	3	20	80	100	4
5	16BCE15X	Elective-1	3	-	3	20	80	100	3
6	16BCEL16	Process Automation Lab		3	3	20	80	100	2
7	16BCE17	Seminar	-	3	-	100	-	100	1
TOTAL			**19**	**6**	**18**	**220**	**480**	**700**	**22**

Elective 1	
16BCE151	Transport Phenomena in Bioprocess System
16BCE152	Mathematical Modeling in Biochemical Engineering
16BCE153	Food Technology
16BCE154	Enzyme Technology

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II SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credit
			Theory	Practical/ Field Work/ Assignment	Duration	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16BCE21	Bio-separation & Downstream Processing	4	-	3	20	80	100	4
2	16BCE22	Bioreactor Design	4	-	3	20	80	100	4
3	16BCE23	Chemical Biochemical Reactions	4	-	3	20	80	100	4
4	16BCE24	Safety Management in Bioprocess Industries	4	-	3	20	80	100	4
5	16BCE25X	Elective-2	3	-	3	20	80	100	3
6	16BCEL26	Downstream Processing Lab		3	3	20	80	100	2
7	16BCE27	Seminar	-	3	-	100	-	100	1
TOTAL			**19**	**6**	**18**	**220**	**480**	**700**	**22**

Elective 2	
16BCE151	Total Quality Management
16BCE152	Nanotechnology and its application in Bioprocess Industries
16BCE153	Biosensors
16BCE154	Bioprocess Modeling and Simulation

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III SEMESTER: Internship

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credit
			Theory	Practical/ Field Work/ Assignment	Duration	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16BCE31	Seminar / Presentation on Internship (After 8 weeks from the date of commencement)	-	-	-	25	-	25	20
2	16BCE32	Report on Internship	-	-	-	25	-	25	
3	16BCE33	Evaluation and Viva-Voce of Internship	-	-	-	-	50	50	
4	16BCE34	Evaluation of Project phase -1	-	-	-	50	-	50	1
TOTAL			**-**	**-**	**-**	**100**	**50**	**150**	**21**

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IV SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credit
			Theory	Practical/Field Work/ Assignment	Duration	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16BCE41	Bioenergy	4	-	3	20	80	100	4
2	16BCE42	Elective-3	3	-	3	20	80	100	3
3	16BCE43	Evaluation of Project phase -2	-	-	-	50	-	50	3
4	16BCE44	Evaluation of Project and Viva-Voce	-	-	-	-	100+100	200	10
TOTAL			**7**	**-**	**6**	**90**	**360**	**450**	**20**

Elective 3	
16BCE421	Biological Waste Treatment
16BCE422	Biological Thermodynamics
16BCE423	Fermentation Technology
16BCE424	Animal Cell Culture and Tissue Engineering

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STATISTICAL METHODS- 16BCE11

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 1

Subject Code	:	16BCE11	**IA Marks**	:	20
No of Lecture Hrs/Week	:	04	**Exam hours**	:	03
Total No. of Lecture Hours	:	52	**Exam Marks**	:	80
Credits	:	04			

Course objectives:

The Students will

1. Equip with statistical tools and concepts that help in decision making.
2. Understand the probability and able to design an experiments

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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).	12	L1 L2
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.	10	L1 L2
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.	10	L3, L4
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	10	L2, L3

(T-test, F-test, Chi Squared distribution, goodness of fit test) analysis of variance (one-way and two-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.	10	L1, L2, L3

Course outcomes:

After studying this course, students will be able to:

1. 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
2. Apply the basic principles of probability and probability distributions to the problems in Biochemical Engineering and to the field of genetics.
3. Demonstrate an understanding of sampling and its various techniques.
4. To draw inferences about the characteristics of population from the samples based on the parametric and non-parametric tests.
5. To conceive and conduct a designed experiment to characterize a process

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Scholarship of knowledge
2. Critical Thinking
3. Problem solving
4. Research Skill
5. Project management and Finance
6. Life long learning

TEXT BOOK

1. Sokal, R. R. and F. J. Rohlf, **Biometry: the principles and practice of statistics in biological research,** W. H. Freeman and Co, Third edition: New York, 1995
2. Veer Bala Rastogi, Fundamentals of Biostatistics, Ane Books Pvt. Ltd., New Delhi, 2009

PROCESS AUTOMATION- 16BCE12

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 1

Subject Code	:	16BCE12	**IA Marks**	:	20
No of Lecture Hrs/Week	:	04	**Exam hours**	:	03
Total No. of Lecture Hours	:	52	**Exam Marks**	:	80
Credits	:	04			

Course objectives:

The Students will

1. Develop the concept of control of a single and multivariable chemical/Biochemical process.
2. Design of controllers to control simple and complex Chemical/Biochemical processes.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
REVIEW OF SYSTEMS: Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Control valve types- linear, equal percentage and quick opening valves. Transient response. Block diagrams.	10	L1 L2
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.	12	L1,L2,L3
Module 3		
SPECIAL CONTROL TECHNIQUES: Advanced control techniques, cascade, ratio, feed forward, adaptive control, selective controls, computing relays, simple alarms, Smith predictor, internal model control, theoretical analysis of complex processes.	11	L3, L4
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.	11	L2, L3,L4
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.	08	L1, L2, L3

Course outcomes:

After studying this course, students will be able to:

1. Evaluate the response of first and higher order system and analyze the stability of

control system
2. Identification of proper advanced control techniques for different process and design of controller for multivariable process control system
3. Understanding the sampled data system and identify the response of discrete system.

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem Solving
3. Collaborative and Multidisciplinary Work
4. Lifelong Learning

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.

REFERENCES:

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.

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BIOPROCESS ENGINEERING- 16BCE13

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 1

Subject Code	:	16BCE13	**IA Marks**	:	20
No of Lecture Hrs/Week	:	04	**Exam hours**	:	03
Total No. of Lecture Hours	:	52	**Exam Marks**	:	80
Credits	:	04			

Course objectives:

The Students will

1. Understand the fundamental background of biological systems
2. Emphasize areas of biochemical processes, essential to an engineer to work in the area of bioprocessing.
3. 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.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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 industry. Classification of micro-organisms, Taxonomy, Environmental and Industrial microbiology.	10	L1 L2
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, **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.	12	L1 L2
Module 3		
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.	10	L3, L4

Continuous culture: optimum dilution rate in an ideal Chemostat. Introduction to fed-batch reactors. Immobilized Cells: Formulations, Characterization and Applications		
Module 4		
MIXED CULTURES: Introduction to mixed cultures, Major Classes of Interactions: Simple Models, Competition between two species, Prey-Predator system, Lotka-Volterra Model Web Interaction, Population dynamics in models of mass action form.	10	L2, L3
Module 5		
INDUSTRIAL BIOPROCESS: Anaerobic process: Ethanol, lactic acid, acetone-butanol production. Aerobic Processes: Citric Acid, Baker's Yeast, Penicillin, High fructose corn syrup production.	10	L1, L2, L3

Course outcomes:

After studying this course, students will be able to:

1. Apply basic & advanced biology in bioprocess engineering.
2. Identify enzymes and explain the kinetics of enzyme catalyzed processes.
3. Understand growth kinetics of microorganism and mixed cultures.
4. Decide various separation procedures in the industrial bioprocess.

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Scholarship of knowledge
2. Critical Thinking
3. Problem solving
4. Research Skill
5. Project management and Finance
6. Life-long learning

TEXT BOOK:

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

REFERENCE BOOKS:

1. James E.Bailey and David F.Ollis **Biochemical Engineering Fundamentals** by. Mc-Graw Hill International Edition, Sixth edition, 2005
2. James Lee, **Biochemical Engineering** –Prentice Hall - 1992.
3. Pelczar **Microbiology Concept and Application -**,5th Edition, McGraw Hill, 2001

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BIOREACTORS -16BCE14

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 1

Subject Code	:	**16BCE14**	**IA Marks**	:	20
No of Lecture Hrs/Week	:	04	**Exam hours**	:	03
Total No. of Lecture Hours	:	52	**Exam Marks**	:	80
Credits	:	04			

Course objectives:

Students Will

1. understand the essential concepts biological reactors
2. learn gas-liquid mass transfer phenomenon in cellular system
3. acquire the collective operations involved in bioreactors and the methods for sterilization of bioreactors
4. study the control of parameters and instrumentation techniques during bioreactors operations

Modules	Teaching Hours	Blooms Level
Module 1		
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.	10	L1 L2
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.	12	L2, L3
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	12	L3
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.	10	L2, L3

Module 5		
STERLISATION 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.	08	L3

Course outcomes:

After studying this course, students will be able to:

1. define, classify and understand the types of reactors used in microorganisms, animal and plant cell cultivation and culture
2. describe the O_2 transfer and use between gas and liquid phases during cellular growth in bioreactors
3. Analyze the difference between batch and continuous bioreactors and sterilization operations
4. Use the control tasks for parameters (pH, T, pO_2, etc.) using different instruments (pH- meters, thermometers, oxygen probe, etc.)

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Project Management and Finance

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** by. Mc-Graw Hill International Edition, Sixth edition, 2005

REFERENCE BOOK

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

TRANSPORT PHENOMENA IN BIOPROCESS SYSTEM- 16BCE151

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 1

Subject Code	:	16BCE151	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives:

The Students will

1. familiarize the concepts of boundary conditions for momentum, heat and mass transfer operations.
2. comprehend the velocity distribution, temperature profiles and concentration distributions

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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	08	L1 L2
Module 2		
Forced Convection Mass Transfer, General Concepts Dimensionless Groups, Correlations for Mass-Transfer Coefficients and Interfacial Area, Mass Transfer Across Free Surfaces Factors Effecting $k_l a$', 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	08	L1, L2
Module 3		
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	08	L3, L4, L5
Module 4		
CONCENTRATION DISTRIBUTIONS IN LAMINAR FLOW:	08	L2, L3

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.		
Module 5		
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	L1, L2, L3

Course outcomes:

After studying this course, students will be able to:

1. Comprehend the Gas-Liquid Mass Transfer in Cellular System
2. Infer, analyze and solve problems for steady state operation for momentum, heat & mass transfer.
3. Analyze steady state shell momentum, energy & mass balances for laminar flow across various boundary conditions.
4. Apply equation of changes in various co-ordinate systems.
5. Infer analogies between momentum, heat and mass transport

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Research Skill
4. Collaborative and multidisciplinary work
5. Independent and reflective learning

TEXT BOOK:

1. Bird, BR,, Stewart W.E.and Lightfoot **E. N., Transport Phenomena**, John Wiely and Sons, Singapore, 2nd Edition 2009.
2. James E.Bailey and David F.Ollis **Biochemical Engineering Fundamentals** by. Mc-Graw Hill International Edition, Sixth edition, 2005
3. Fruskey, Fan Yuan David F. Katz, **Transport Phenomena in Biological Systems** (Pearson Prentice Hall Bioengineering) 2nd edition, 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.

MATHEMATICAL MODELING IN BIOCHEMICAL ENGINEERING - 16BCE152

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 1

Subject Code	:	16BCE152	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives:

The Students will

1. Understand physical systems in Chemical and Biochemical engineering.
2. Develop mathematical models for Chemical and Biochemical systems.
3. Solve and analyze process models using different mathematical techniques.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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–Liquid equilibria for binary mixtures, Calculation of Bubble Point Dew point for ideal binary mixture	9	L1, L2, L3
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	L2, L3
Module 3		
Design: Double Pipe Heat Exchanger (Area, Length and Pressure drop), Shell & Tube Heat Exchanger (Area, Number of tubes, Pressure drop)	7	L2, L3, L4
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	8	L2, L3
Module 5		
Mathematical Modeling and Solutions to the Following: Basic tank model – Level V/s time, batch Distillation–Vapour composition with CSTRs in series	08	L2, L3

Course outcomes:

After studying this course, students will be able to:

1. Formulate and develop governing equations for chemical and Biochemical

systems and solve using different numerical techniques.
2. Model and design different Bioreactors.
3. Design different heat exchanger equipment.
4. Apply mass, heat and momentum balance equation to model different chemical and Biochemical process.

Question paper pattern:
The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes
1. Critical Thinking
2. Problem solving
3. Use modern tool
4. Life - long Learning

TEXT BOOKS:
1. Jenson, V. G. and Jeffreys, F. V.,Mathematical methods in Chemical Engineering,2nd edition, Academic press, Elsevier, India, 2012.
2. Jana, Aimya K., Chemical Process Modelling and Computer Simulation, 2nd edition, PHI Learning Private Limited, New Delhi, India, 2011.
3. William. L Luyben, Process Modeling Simulation and Control for Chemical Engineering 2nd Edition, McGraw Hill, 1990.

REFRENCE BOOKS:
1. Gaikwad, R.W, and Dhirendra, Process Modelling and Simulation, 2nd Edition, Denetted& Co., 2006.
2. Grewal, B. S., Higher Engineering Mathematics, 40th edition, Khanna Publishers, Delhi, India, 2009.

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FOOD TECHNOLOGY - 16BCE153

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 1

Subject Code	:	16BCE153	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives:

The Students will

1. Empower the students with the professional competence and expertise of Food Technology.
2. Enable the students to understand food composition and its physicochemical, nutritional, microbiological and sensory aspects and enzymatic reactions during storage
3. Familiarize the students about the processing and preservation techniques of pulses, oilseeds, spices, fruits and vegetables, meat, fish, poultry, milk & milk products,
4. Emphasize the importance of food safety, food quality, food plant sanitation, food laws and regulations, food engineering and packaging in food industry.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
Introduction and Quality Attributes of Food : Function of foods. Food in relation to health. Aim of food science and technology. Quality attributes – Appearance factors, Textural factors, Flavour factors. Visual and objectively measurable attributes. Aroma of foods – introductory ideas, formation, chemistry and analysis. Taste – introductory ideas, formation and chemistry. Additional quality; quality standards, quality control. Introduction to sensory evaluation of foods and beverages. **Formation and Chemistry of Food:** Carbohydrates. Proteins. Lipids. Vitamins. Minerals. Water. Biotin. Choline. Phytochemicals.	8	L1 L2
Module 2		
Food Processing and Preservation: Food deterioration – Causes. Aims and objectives of preservation and processing. Unit operations in processing. Different methods of food preservation – low temperature, high temperature, preservatives, osmotic pressure, dehydrations. food irradiation; processing and preservations of milk and dairy, vegetables and fruits, cereals, legumes and nuts, meat and meat products, fats and oils, beverages, sugars, sweeteners, honey and confectionary, salt and spices.	8	L1 L2

Module 3		
Enzymatic and Non-Enzymztic reactions during storages: Introduction to enzymes. Nature and function of enzymes. Classification of enzymes. Hydrolases – Esteraus, amylases, pectic enzymes. Proteases. Oxidoreductases – phenolases, glucose oxidase, catalose, peroxidase, lipoxygenase, xantine oxidase. Immobilized enzymes. Uses and suggested uses of enzyme in food processing. Non-enzymatic reactions.	8	L3, L4
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 choking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety.	7	L2, L3
Module 5		
Food Contamination and Adulteration: Types of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards. **Modern Trends in Food Science:** Biotechnology in food. Biofortification. Nutraceuticals. Organic foods. Low cost nutrient supplements. Packaging of foods and nutrition labelin. Careers in food science and food industries.	08	L1, L2, L3

Course outcomes:

After studying this course, students will be able to:

1. Comprehend the physical properties of food and its transportation.
2. Identify sources of contaminants, adulterants with the prevention for safe and healthy food.
3. Discern different technologies involved in food processing.
4. Select biocompatible packaging and additives for food products

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Scholarship & Knowledge
2. Critical Thinking
3. Research skill
4. Life long learning

TEXT BOOK:

1. Bird, BR,, Stewart W.E.and Lightfoot **E. N., Transport Phenomena**, John Wiely and Sons, Singapore, 2nd Edition 2009.
2. James E.Bailey and David F.Ollis **Biochemical Engineering Fundamentals** by. Mc-Graw Hill International Edition, Sixth edition, 2005

3. Fruskey, Fan Yuan David F. Katz, **Transport Phenomena in Biological Systems** (Pearson Prentice Hall Bioengineering) 2nd edition, 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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ENZYME TECHNOLOGY- 16BCE154

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 1

Subject Code	:	16BCE154	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives:

The students will

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

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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	L1 L2
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	L2,L3,L4
Module 3		
CHEMICAL NATURE OF ENZYME CATALYSIS: Sigmoidal kinetics and allosteric enzymes, co-enzymes, significance of sigmoidal behaviour.	8	L2, L3
Module 4		
APPLICATIONS: Investigation of enzymes in biological preparation, extraction and purification, enzymes as analytical reagents	7	L3, L4
Module 5		
INSTRUMENTAL TECHNIQUES: Instrumental techniques available for using enzymatic analysis, applications in medicine, industries, and biotechnological applications	8	L2, L3, L4

Course outcomes:

After studying this course, students will be able to:

1. The knowledge on enzyme and enzyme reactions will be the key step in to proceed towards various concepts in biochemical engineering
2. The theoretical and practical aspects of kinetics will provide the importance and utility of enzyme kinetics towards research.
3. Ideas on Processing, extraction and Purification of enzymes at an industrial scale will

be helpful to work technologically.

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Research Skill
4. Use of Modern Tools

TEXT BOOKS:

1. Trevor Palmer, "**Understanding Enzymes**"-4th edition, 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.

PROCESS AUTOMATION LABORATORY- 16BCE16

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 1

Subject Code	:	16BCE16	**IA Marks**	:	20
No of Lecture Hrs + Lab/Week	:	01 + 03	**Exam hours**	:	03
Credits	:	02	**Exam Marks**	:	80

Course objectives:

The students will

1. Experimentally verify the process control concepts developed in theory subject.
2. Examine the first and second order system.
3. Identify the effect of P, PI and PID control action and Characteristic of different valves.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Experiments	Blooms Level
1. Time constant of a Thermometer response	L3, L4
2. Second Order system U Tube Monometer	L3, L4
3. Single Tank – Step response	L3, L4
4. Interacting tanks- Step Response	L3, L4
5. Interacting tanks Pulse Response	L3, L4
6. Non-Interacting tanks- Step Response	L3, L4
7. Non-Interacting tanks- Pulse Response	L3,L4
8. P, PI and PID controller trainer	L3,L4, l5
9. Valve characteristics	L3, L4

Course outcomes:

After studying this course, students will be able to:

1. Apply theoretical knowledge of response of first order response by hand on with thermometer system and single tank flow system.
2. Acquire practical knowledge of second order system response with tank in series system and U tube manometer.
3. Control level and temperature using P, PI and PID controller and examine valve characteristics.

Conduct of Practical Examination:

- All laboratory experiments are to be included for practical examination.
- Students are allowed to pick one experiment from the lot.
- Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
- Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes

1. Critical Thinking
2. Usages of Modern Tools
3. Collaborative and Multidisciplinary Work
4. Life Long Learning
5. Independent and Reflective Learning

REFERENCES:

1. George Stephanopoules, "**Chemical process control, An Introduction to Theory and Practical**" - Prentice Hall, New Delhi, 1998.
2. Smith C A and Corripio A B "**Principles and practice of automotive process control**"- John Wiley, New York, 1976.
3. Luyben "**Process Modelling, Simulation and Control for chemical Engineers**"- 2nd edn„ McGraw Hill, 1990.

SEMINAR- 16BCE17

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 1

Subject Code	:	16BCE17	**IA Marks**	:	100
No of Lecture Hrs + Lab/Week	:	02	**Exam hours**	:	
Credits	:	01	**Exam Marks**	:	

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

BIOSEPARATION AND DOWNSTREAM PROCESSING- 16BCE21

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 2

Subject Code	:	16BCE21	**IA Marks**	:	20
No of Lecture Hrs/Week	:	04	**Exam hours**	:	03
Total No. of Lecture Hours	:	52	**Exam Marks**	:	80
Credits	:	04			

Course objectives:

The students will

1. Understand downstream processing techniques for processing of biomolecules with emphasis on purification of bio-products
2. Comprehend the membrane separations and freeze drying techniques

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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.	10	L1 L2
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, numericals.	12	L1, L2, L3, L4
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	12	L3, L4
Module 4		
MEMBRANE SEPARATION PROCESSES Membrane – based separations theory; Design and configuration of	10	L2, L3

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 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 equipments, lyophilization, principle of lyophilization, working and applications of lyophilization and formulations	08	L1, L2, L3

Course outcomes:

After studying this course, students will be able to:

1. Describe the principles that underlie major unit operations like homogenization, centrifugation, chromatography, and ultrafiltration used in downstream processing .
2. Define terms associated with downstream processing and downstream process development
3. Determine appropriate operating ranges and scale-up parameters for downstream processing steps
4. Perform basic scale-up calculations for downstream unit operations

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Research Skill

TEXT BOOK

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

BIOREACTOR DESIGN - 16BCE22

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 2

Subject Code	:	16BCE22	**IA Marks**	:	20
No of Lecture Hrs/Week	:	04	**Exam hours**	:	03
Total No. of Lecture Hours	:	52	**Exam Marks**	:	80
Credits	:	04			

Course objectives:

Students Will

1. Understand the basics for design as per the codes & standards for the process and mechanical design of bioreactors used in the bioprocess industry.
2. acquire basic understanding of design parameter, complete knowledge of design procedures for commonly used bioreactors, agitators, enclosures and other parts
3. learn applications of detailed process design of bioreactor

Modules	Teaching Hours	Blooms Level
Module 1		
INTRODUCTION TO DESIGN: Basic considerations in design. General design procedure. Equipment classification. Various components of process equipment. Design parameters. Pressure vessel codes. Material selection. Factors affecting design.	10	L1 L2
Module 2		
MECHANICAL ASPECTS OF BIOREACTOR DESIGN: Introduction, requirement for construction of bioreactor, guidelines for bioreactor design, bioreactor vessels, geometry of vessel, Design of flange, design procedures. **Numerical problems**	12	L2, L3
Module 3		
DESIGN OF AGITAOR AND POWER RATING: Design of vessel sizing with agitation or mixing, types of agitators, baffles, Design of agitator shaft, power requirement calculations, Numerical problems	12	L3
Module 4		
DESIGN OF VESSEL CLOSURES: Various Vessel closures such as Flat plates or covers formed, torispherical, elliptical, hemispherical and cylindrical designs. Numerical problems	10	L2, L3
Module 5		
BIOLOGICAL REACTOR: Detailed process design of biological reactor: Activated sludge process, rotating biological contactor, trickling bed filters, up flow anaerobic sludge blanket digester, Numerical problems.	08	L3

Course outcomes:

On completion of this course the students will be able to

1. understand the basic calculations for design of pressure vessels.
2. design bioreactor and various components of bioreactor vessel
3. demonstrate detailed process design of bioreactor

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Project Management and Finance

TEXT BOOK:

1. Coulson and Richardson, Design for Chemical Engineering, Volume 6, Butterworth Heinemann, 1990.
2. Galvin Towler and Ray Sinnott, Chemical Engineering Design, Elsevier, 2008.
3. M.V Joshi, Process Equipment Design, Macmillan & Co, India, 3rd Edition, New Delhi, 1998.
4. SD Dawande, Process Design of Equipment Volume 1, Central Techno Publications, 2003.

REFERENCE BOOK

1. Perry and Green, Chemical Engineering Handbook, 8th Edition, McGrawHill, 2008.
2. D.Q.Kern, "**Process Heat Transfer"-** McGraw Hill, 1950,
3. Brownell & Young, Process Equipment Design – Vessel Design, John Willey, 1951
4. IS Code ,"Pressure Vessel Code – IS 2825", B.I.S., New Delhi, 1969.
5. Tapabrata Panda, Bioreactors Analysis and Design, Tata McgRawHill Education Pvt. Ltd, August, 2011

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CHEMICAL AND BIOCHEMICAL REACTIONS - 16BCE23

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 2

Subject Code	:	16BCE23	**IA Marks**	:	20
No of Lecture Hrs/Week	:	04	**Exam hours**	:	03
Total No. of Lecture Hours	:	52	**Exam Marks**	:	80
Credits	:	04			

Course Objectives:

Students will

1. Apply concepts of Reaction kinetics, fluid flow behavior and mass transfer to understand the Non – ideal & Heterogeneous reaction system.
2. Design of Chemical and Biochemical reactors with multiple and single chemical reactions

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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.	10	L1, L2
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.	12	L2, L3
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.	12	L2, L3
Module 4		
INTERNAL TRANSPORT PROCESSES IN POROUS CATALYSTS: Intra pellet mass and heat transfer, Evaluation of effectiveness factor, mass and heat transfer with reaction.	10	L2, L3
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	08	L3,L4

reactor model, Trickle bed reactor model.		

Course Outcome

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**.**
2. Analyze the flow behavior, contacting, conversion and performance of non-ideal reactors using various models and comparison with ideal reactor.
3. Apply knowledge of reaction kinetic and flow behavior to design heterogeneous catalytic reactors for different reaction conditions.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Research Skill
4. Independent and Reflecting leaning
5. Use of Modern Tools

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

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 , (Third Edtion), 2005.
2. Smith J.M, Chemical Engineering Kinetics, 3rd Edition, McGraw-Hill, 1984.

SAFETY MANAGEMENT IN BIOPROCESS INDUSTRIES- 16BCE24

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 2

Subject Code	:	16BCE24	**IA Marks**	:	20
No of Lecture Hrs/Week	:	04	**Exam hours**	:	03
Total No. of Lecture Hours	:	52	**Exam Marks**	:	80
Credits	:	04			

Course objectives:

Students will

- Acquainted with various aspects of Intellectual rights and their usage to modern technology
- Understand the hazards and regulation of handling biohazard materials

Revised Bloom's Taxonomy Levels:

L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	**Teaching Hours**	**Blooms Level**
Module 1		
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.	09	L1, L2
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	10	L1, L2
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.	12	L1, L2, L5
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	09	L1, L2, L4

Biosafety (Bt Bringal and Bt cotton, Golden Rice)		
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.	12	L1, L2

Course outcomes:

After studying this course, students will be able to:

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

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Usage of modern tools
3. Research Skill
4. Ethical Practices and social responsibility
5. Independent and reflective thinking

TEXT BOOK

1. Deepa Goel & Shomini Prasar, IPR, Biosafety, and Bioethics, Pearson Press, New Delhi 2013.
2. Thomas JA and Fuch RI (2002) Biotechnology and safety assessment, Academic press 2002.

REFERENCE

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

TOTAL QUALITY MANAGEMENT -16BCE251

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER 2

Subject Code	:	16BCE251	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives: Students will

1. Understand the main principles of business and social excellence.
2. use models and quality management methodology for the implementation of total quality management at all scope of business and public sector.
3. develop an understanding of total quality management principles, frameworks, tools and techniques for effective real life applications in both manufacturing and services.

Modules	Teaching Hours	Blooms Level
Module 1		
CONCEPTS OF TQM: Basics of total quality, Guru's of TQM, Philosophy of TQM, customer focus, organization, quality philosophies of Deming, Crossby.	06	L1 L2
Module 2		
TQM PROCESS: QC tools, problem solving methodologies, cost of quality, quality circles, bench marking, strategic quality planning.	09	L2, L3
Module 3		
TQM SYSTEMS: Quality policy deployment, quality function deployment, standardization, designing for quality, manufacturing for quality.	08	L3
Module 4		
QUALITY SYSTEM: Need for ISO 9000 system, advantages, clauses of ISO 9000, Implementation of ISO 9000, quality auditing, case studies.	10	L5
Module 5		
IMPLEMENTATION OF TQM: KAIZEN, 5s, JIT, POKAYOKE, Taguchi methods, case studies.	06	L3

Course outcomes:

At the end of the course, the students will be able to

1. develop an understanding on quality management philosophies and frameworks
2. develop in-depth knowledge on various tools and techniques of quality management
3. learn the applications of quality tools and techniques in both manufacturing and service industry

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Research skills
3. Collaborative and multidisciplinary work
4. Ethical practices and social responsibility

TEXT BOOK

1. Dale H. Besterfield, Total Quality Management, PHI, India 2016.
2. Rose, J.E, Total Quality Management, Kogan Page Ltd. 1993.

REFERENCE BOOKS

1. John Bank., The essence of total quality management, PHI, 1993.
2. Greg Bonds *et al*, Beyond Total Quality Management, McGraw-Hill, 1994.

NANOTECHNOLOGY AND ITS APPLICATION IN BIOPROCESS INDUSTRIES -16BCE252

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 2

Subject Code	:	16BCE252	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives: Students will

1. learn basic knowledge in the interface between chemistry, physics and biology on the nano structural level with a focus on bioprocess industries use
2. understand Basic concepts of BioMEMS and their use in drug delivery
3. know the available nanomaterials in biological system

Modules	Teaching Hours	
Module 1		
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.	08	L1 L2
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	08	L2, L3
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.	08	L3
Module 4		
BIOMEMS: Introduction and Overview, BioMEMS Applications: Case Studies in Biomagnetic Sensors, Applications of optical and chemical transducers. Ultimate Limits of Fabrication and Measurement, Recent	10	L5

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.	05	L3

Course outcomes:

At the end of the course, the students will be able to

1. understand the basic concepts in nanotechnology
2. remember the applications nanotechnology
3. learn the significance of nanotechnology and its applications in the field of bioprocess industries

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Research skills
3. Collaborative and multidisciplinary work

TEXT BOOK:

1. Charles P. Poole, Jr., Frank J. Owens, Introduction to Nanotechnology, John Wiley and Sons, 2009.
2. Handbook of Nanostructured Materials and Nanotechnology, Vol. 1-5, Academic Press, Boston, 2000.

REFERENCE BOOK

1. CNR Rao, Nanoworld- An introduction to science and technology, JNCASR, Bangalore, 2010.

BIOSENSORS -16BCE253

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 2

Subject Code	:	16BCE253	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives:

Students will

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

Modules	Teaching Hours	Blooms Level
Module 1		
INTRODUCTION:A historical perspective; Definition and Expanding Needs of Biosensors; Advantages and limitations; Biosensor Economics; various components of biosensors	06	L1 L2
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	09	L2, L3
Module 3		
TRANSDUCERS IN BIOSENSORS: Various types of transducers; principles and applications; Bio-, chemi-, and electrochemiluminescence for fiber-optic biosensors; Fluorescence-based fiber-optic biosensors	08	L3
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	10	L5
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.	06	L3

Course outcomes:

At the end of the course, the students will be able to

1. Explain the basic definition used in the field of sensors.
2. Describe the experimental techniques used for optical sensors, fluorescence-based

fibre-optic and biosensors.

3. Model the kinetics of biochemical in order to investigate the specific reaction in the biosensor.
4. Presents and interprets the different applications of biosensors

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Research skills
3. Collaborative and multidisciplinary work
4. Lifelong learning

TEXT BOOK:

1. Rajmohan Joshi, Biosensors (1e), Gyan Books, 2006
2. Cooper J.M. and Anthony E.G, Biosensors (2e), Oxford University Press, 2004.
3. Turner A.P.F, Karube.I and Wilson,G.S, Biosensors Fundamentals and applications, Oxford Univ. Press, 1990

REFERENCE BOOKS

1. Sadana.A, Biosensors: Kinetics of Binding and Dissociation Using Fractals (1e), Elsevier B.V, 1995
2. Ashok M and Kim Rogers, Enzyme & Microbial Biosensors: Techniques and Protocols (Methods in Biotechnology) (1e), Humana Press, 1998.
3. Ashok M and Kim Rogers, Affinity Biosensors: Techniques and Protocols (Methods in Biotechnology) (1e), Humana Press, 1998.
4. DamiaBarcelo, Biosensors for the Environmental Monitoring of Aquatic Systems: Bioanalytical and Chemical Methods for Endocrine Disruptors (1e), Springer, 2009

BIOPROCESS MODELING AND SIMULATION - 16BCE254

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 2

Subject Code	:	16BCE254	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives:

Students will

1. Learn and develop mathematical models of phenomena involved in various biochemical engineering processes
2. Know the feasible solutions for different models developed

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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 lumped & distributed parameter models, with examples for all the models.	07	L1, L2
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	L2, L3, L4, L6
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, Numericals.	08	L2, L3, L4, L6
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	08	L2, L3

electrodes, Optical and photometric biosensors.		
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	L2, L3, L5

Course outcomes:

After studying this course, students will be able to:

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

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Research Skill

TEXT BOOK

1. William. L Luyben, Process Modeling Simulation and Control for Chemical Engineering 2nd Edition, 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 and Wilson,G.S, Biosensors Fundamentals and applications, Oxford Univ. Press, 1990.
2. John H. Seinfeld and Leon Lapidus., Mathematical Methods in Chemical Engg., (Vol. 3), Process Modeling, Estimations and Identification. Prentice Hall, 1974.
3. Shyam S. Sablani., Handbook of Food and Bioprocess Modeling Techniques. C R C

DOWNSTREAM PROCESSING LABORATORY- 16BCE26

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 2

Subject Code	:	16BCE26	**IA Marks**	:	20
No. of Lecture Hrs + Lab/Week	:	01 + 02	**Exam hours**	:	03
Credits	:	02	**Exam Marks**	:	80

Course objectives:

Students will

1. Understand the nature of the end product, its concentration, stability and degree of purification required
2. Recover and subsequent purification of target biological products.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Experiments	Blooms Level
1. Coagulation Jar Test	L3, L4, L5
2. Effect of Temperature on enzyme activity	L1, L4, L5
3. Aqueous two phase extraction	L3, L4, L5
4. SDS PAGE Electrophoresis	L3, L4, L5
5. Leaf filter	L3, L4, L5
6. Ion exchange Chromatography	L2, L3, L4
7. Simple Distillation	L1, L2, L3
8. Ammonium sulphate precipitation	L1, L4, L5
9. Single stage leaching	L3, L4, L5

Course outcomes:

After studying this course, students will be able to:

1. Apply downstream processing opertions.
2. Determine appropriate operating ranges and scale-up parameters for downstream processing steps
3. Perform basic scale-up calculations for downstream unit operations

Conduct of Practical Examination:

- All laboratory experiments are to be included for practical examination.
- Students are allowed to pick one experiment from the lot.
- Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
- Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes

1. Critical Thinking
2. Usages of Modern Tools
3. Collaborative and Multidisciplinary Work
4. Life Long Learning
5. Independent and Reflective Learning

TEXT BOOKS:

3. P.A. Belter, E.L. Cussler And Wei-Houhu – Bioseparations – Downstream Processing For Biotechnology, Wiley Interscience Pun. (1988).
4. R.O. Jenkins, (Ed.) – Product Recovery In Bioprocess Technology – Biotechnology By Open Learning Series, Butterworth-Heinemann (1992).

REFERENCES:

3. J.C. Janson And L. Ryden, (Ed.) – Protein Purification – Principles, High Resolution Methods And Applications, VCH Pub. 1989.

SEMINAR- 16BCE27

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 2

Subject Code	:	16BCE27	**IA Marks**	:	100
No of Lecture Hrs + Lab/Week	:	02			
Credits	:	01			

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

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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THIRD SEMESTER M.TECH – BIOCHEMICAL ENGINEERING

SEMINAR ON INTERNSHIP -16BCE31

Subject Code	:	16BCE31	IA Marks	:	25

The students are required to make a report and make presentation on internship after 8 weeks of their training. A committee to be constituted by HOD to evaluate for 25 marks as Internal Assessment.

REPORT ON INTERSHIP -16BCE32

Subject Code	:	16BCE32	IA Marks	:	50

After successful completion of internship, student has to submit a detailed report on the same. Internal guide in consultation with guide of the industry should evaluate for IA marks.

EVALUATION AND VIVA-VOCE OF INTERNSHIP -16BCE33

Subject Code	:	16BCE33	Exam Marks	:	75
Credits	:	20			

An external examiner has to be called for viva voce and internal guide together with external examiner should evaluate the performance as examination.

EVALUVATION PROJECT PHASE I - 16BCE34

Subject Code	:	16BCE34	IA Marks	:	25
Credits	:	01			

Project work has to be assigned at II Semester itself. Student has to complete literature survey and methodology of the work and submit a report at the end of III Semester which should be evaluated as IA Marks by the departmental committee.

BIOENERGY- 16BCE41

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 4

Subject Code	:	16BCE41	**IA Marks**	:	20
No of Lecture Hrs/Week	:	04	**Exam hours**	:	03
Total No. of Lecture Hours	:	52	**Exam Marks**	:	80
Credits	:	04			

Course objectives:

Students will

1. Gain a comprehensive understanding of the principle and application of bioenergy systems
2. Understand the availability of biomass feedstocks in different area and weather condition and their potential attributes to biofuels production.
3. Understand concepts of the second and third generation of bioenergy, and the conversion processes of biomass feedstock to biofuels.

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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.	12	L1 L2
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.	10	L1 L2
Module 3		
BIODESIEL: Defination 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 liquid biofuels.	12	L1 L2
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.	10	L2, L3

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.	08	L1, L2, L3, L4

Course outcomes:

After studying this course, students will be able to:

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

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving

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* , Mc Graw 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 (Ed.), *Biofuels (Advances in Biochemical Engineering/Biotechnology Series*, Springer-Verlag Publishers, Berlin, 2007.
4. G D Rai, *Nonconventional Energy Sources*, Khanna Publications, 4th Edition, 2010.

BIOLOGICAL WASTE TREATMENT - 16BCE421

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 4

Subject Code	:	16BCE421	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives:

Students will

1. Acquire the knowledge on wastewater that includes foreign matter with fine and coarse matter with physical, chemical and biological contaminants requires the physical and chemical operations and biological process with primary, secondary and advanced treatment options depending on the disposal options.
2. Produce an environmentally safe fluid waste stream (or treated effluent) and solid waste (or treated sludge) suitable for disposal or reuse usually as farm fertilizers

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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	8	L1 L2
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.	8	L1 L2
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, Reactors and their hydraulic characteristics, Reaction kinetics and Reactor selection. (Batch, Plug flow, Completely stirred tank reactor and packed and fluidized bed reactor).	8	L3, L4
Module 4		
Biological treatment processes: Aerobic/Anaerobic attached and suspended growth treatment processes- Activated sludge process:	7	L2, L3

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		
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.	08	L1, L2, L3

Course outcomes:

After studying this course, students will be able to:

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

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

Critical Thinking
Problem solving
Ethical practices and social resposibility

TEXT BOOKS:

1. Eckenfelder and O'Conner, Biological Waste Treatment, 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. Webber WJ, Physicochemical processes for water quality
3. Fasir GM , Geyer JG and Okun- Waste water engineering
4. RonandDroste, Theory and practice of water and wastewater treatment, John Wiley and sons, Canada, 2005.
5. George Tchobanoglous and Franlin L. Burton, *Wastewater Engineering- Treatment, Disposal and Reuse*, Tata McGraw Hill Publishing Co. Ltd, 1990.

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BIOLOGICAL THERMODYNAMICS-16BCE422
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER 4

Subject Code	:	**16BCE422**	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives:

Students Will

1. Apply the basic concepts of thermodynamics like heat, enthalpy, internal energy, work, energy and power etc.
2. study the laws of thermodynamics and their applications to biological systems.

Modules	Teaching Hours	Blooms Level
Module 1		
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	L1 L2
Module 2		
FUNDAMENTAL CONCEPTS OF THERMODYNAMICS: System and Surroundings, First law of thermodynamics -Internal energy, enthalpy, Heat capacity, applied examples from biochemistry.	8	L2, L3
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	L3
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, Protien solubility, stability and dynamics.	8	L2, L3
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	L3

Course outcomes:

After studying this course, students will be able to:

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

Question paper pattern:
The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Project Management and Finance

TEXT BOOK

1. Donald T. Haynie, *Biological Thermodynamics*, Cambridge press, 2008.

REFERENCE BOOK

1. Robert A. Alberty, *Thermodynamics of Biochemical Reactions*, John willy publications, 2003

FERMENTATION TECHNOLOGY 16BCE423
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER 4

Subject Code	:	16BCE423	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No. of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives:
Students will

1. Study basics of fermentation processes and different strategies for isolation and preservation of industrially important microorganisms, design of media and development of inocula for fermentations
2. study different types media preparation for industrial fermenters , their accessories and design
3. learn basic concepts of control systems and the methods to measure the process variable from instruments
4. review different types of recovery and purification of fermentation products

Modules	Teaching Hours	Blooms Level
Module 1		
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.	8	L1 L2
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.	7	L2, L3
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	8	L3
Module 4		
INSTRUMENTATION AND CONTROL: Control Systems: Manual, automatic and their combination; Methods of measurement of for Process	8	L2, L3

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 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;	08	L3

Course outcomes:
After studying this course, students will be able to:
1. to devise the isolation and improvement methods base on metabolic pathway of the product
2. design, formulate and sterilize the media for different inocula on large scale
3. to understand design and operation of basic control loops with respect to fermentation process

Question paper pattern:
The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes
1. Critical Thinking
2. Problem solving
3. Use of modern tools
4. Research Skill
5. Life-long learning

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

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

ANIMAL CELL CULTURE & TISSUE ENGINEERING - 16BCE423

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER 4

Subject Code	:	16BCE424	**IA Marks**	:	20
No of Lecture Hrs/Week	:	03	**Exam hours**	:	03
Total No.of Lecture Hours	:	39	**Exam Marks**	:	80
Credits	:	03			

Course objectives:

Students will

1. Understand techniques in animal cell and tissue culture, in vitro conservation, protoplast culture, micro propagation and genetic engineering.
2. Learn the differences between primary vs continuous culture, normal cells vs transformed cells, monolayer vs suspension culture.
3. Study on tissue engineering and the regulations involved with pharmaceutical and medical tissue products

Revised Bloom's Taxonomy Levels: L1 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analyzing, L5 – Evaluating, and L6 - Creating

Modules	Teaching Hours	Blooms Level
Module 1		
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	8	L1 L2
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.	8	L1 L3
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	8	L1 L4
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.	8	L1 L2
Module 5		
Tissue Engineering of Skin, Bone, tendon, Adipose Tissue Engineering Introduction, FDA Regulation, Regulation of Pharmaceutical / Medical Human Tissue Products in Europe/USA, Other considerations Relevant to Engineered Tissues.	7	L1 L2

Course outcomes:

At the end of the course, the students will be able

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

Question paper pattern:

The question paper will have ten questions. Each full question consists of 16 marks. There will be 2 full questions (with a maximum of four sub questions) from each module. Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

Graduate Attributes

1. Scholarship of Knowledge
2. Critical Thinking
3. Ethical practices and social responsibility

TEXT BOOKS

1. Ruiereis, Introduction to tissue engineering, 2006
2. Tissue Engineering by Clemens Van Blitterswijk
3. Tissue Engineering by John P. Fisher, A G Mikos & Joseph D. Bronzino, CRC Press, 2007.

REFERENCE BOOKS

1. Methods of Tissue Engineering by Anthony Atala & P Lanza, Academic Press Elsevier 2006.
2. Biocatalytic Membrane Reactor by Drioli, Taylor & Francis, 2005
3. Translational approaches in Tissue Engineering and regenerative medicine.

EVALUVATION PROJECT PHASE II - 16BCE43

Subject Code	:	14BCE44	IA Marks	:	50
Credits	:	03			

EVALUVATION PROJECT WORK AND VIVA VOCE - 16BCE44

Subject Code	:	16BCE44	IA Marks	:	-
Exam hours	:	03	Exam Marks	:	100+100
Credits	:	10			