VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.Tech- Bio-Chemical Engineering

I Semester **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
14BCE11	Process Automation	4	2	3	50	100	150	4
14BCE12	Bioprocess Engineering	4	2	3	50	100	150	4
14BCE13	Bio-separation & Downstream Processing	4	2	3	50	100	150	4
14BCE14	Bioreactors	4	2	3	50	100	150	4
14BCE15X	Elective - 1	4	2	3	50	100	150	4
14BCE16	**Lab Component**	--	3	3	25	50	75	2
14BCE17	Seminar	--	3	--	25	--	25	1
Total		**20**	**16**	**18**	**300**	**550**	**850**	**23**

Elective – 1

14BCE151	Transport Phenomena in Bioprocess System	14BCE153	Food Technology
14BCE152	Mathematical Modeling in Biochemical Engineering	14BCE154	Enzyme Technology

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M.Tech- Bio-Chemical Engineering

II Semester **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
14BCE21	Statistical Methods	4	2	3	50	100	150	4
14BCE22	Safety Management in Bio-Process Industries	4	2	3	50	100	150	4
14BCE23	Chemical and Biochemical Reactions	4	2	3	50	100	150	4
14BCE24	Bioreactor Design	4	2	3	50	100	150	4
14BCE25X	Elective-2	4	2	3	50	100	150	4
14BCE26	Lab Component		3	3	25	50	75	2
14BCE27	Seminar	--	3	--	25	--	25	1
	**Project Phase-I (6 week Duration)	--	--	--	--	--	--	--
Total		**20**	**16**	**18**	**300**	**550**	**850**	**23**

Elective – 2

14BCE251 Total Quality Management

14BCE252 Nanotechnology and its application in Bioprocess Industries.

14BCE253 Biosensors

14BCE254 Process Modeling and Simulation

**** Between the II Semester and III Semester, after availing a vacation of 2 weeks.**

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M.Tech- Biochemical Engineering

III Semester: INTERNSHIP **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		
14BCE31	Seminar / Presentation on Internship (After 8 weeks from the date of commencement)	-	-	-	25	-	25	1
14BCE32	Report on Internship	-	-	-		75	75	15
14BCE33	Evaluation and Viva-voce	-	-	-	–	50	50	4
	Total	**-**	**-**	**-**	**25**	**125**	**150**	**20**

* The student shall make a midterm presentation 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.

****Between the III Semester and IV Semester after availing a vacation of 2 weeks.**

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.Tech- Biochemical Engineering

IV Semester **CREDIT BASED**

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Field Work / Assignment / Tutorials		I.A.	Exam		
14BCE41	Bioenergy	4	2	3	50	100	150	4
14BCE42X	Elective-3	4	2	3	50	100	150	4
14 BCE 43	Evaluation of Project Phase-I	-	-	-	25	-	25	1
14 BCE 44	Evaluation of Project Phase-II	-	-	-	25	-	25	1
14 BCE 45	Evaluation of Project Work and Viva-voce	–	-	3	-	100+100	200	18
Total		**8**	**04**	**09**	**150**	**400**	**550**	**28**
Grand Total (I to IV Sem.) : 2400 Marks; 94 Credits								

Elective – 3

14BCE 421	Biological Waste Treatment
14BCE422	Biological Thermodynamics
14BCE423	Fermentation Technology
14BCE424	Animal Cell Culture and Tissue Engineering

Note:

1) Project Phase – I**:** 6 weeks duration shall be carried out between II and III Semesters. Candidates in consultation with the guides shall carryout literature survey / visit to Industries to finalize the topic of dissertation.
2) Project Phase – II**:** 16 weeks duration during III Semester. Evaluation shall be taken during the Second week of the IV Semester. Total Marks shall be 25.
3) Project Evaluation: 24 weeks duration in IV Semester. Project Work Evaluation shall be taken up at the end of the IV Semester. Project Work Evaluation and Viva-Voce Examinations shall be conducted. Total Marks shall be 250 (Phase I Evaluation: 25 Marks, Phase –II Evaluation: 25 Marks, Project Evaluation marks by Internal Examiner (guide): 50, Project Evaluation marks by External Examiner: 50, marks for external and 100 for viva-voce).

   Marks of Evaluation of Project:

   - The I.A. Marks of Project Phase – I & II shall be sent to the University along with Project Work report at the end of the Semester.

4) During the final viva, students have to submit all the reports.
5) The Project Valuation and Viva-Voce will be conducted by a committee consisting of the following:

   a) Head of the Department (Chairman)
   b) Guide
   c) Two Examiners appointed by the university. (Out of two external examiners at least one should be present).

FIRST SEMESTER M TECH – BIOCHEMICAL ENGINEERING

PROCESS AUTOMATION-14BCE11

Subject Code	:	14BCE11	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

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.

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.

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.

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.

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.

BIOPROCESS ENGINEERING -14BCE12

Subject Code	:	**14BCE12**	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

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.

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. 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.

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.

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

BIOSEPARATION AND DOWNSTREAM PROCESSING- 14BCE13

Subject Code	:	14BCE13	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

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,

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

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 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

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. Elliott Goldberg, Handbook of downstream processing, Blackie Academic and Professional, 1997.

2. Verrall, M.S. Downstream processing of natural products: A practical handbook: John Wiley & Sons Ltd., England, UK. 1996.
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

BIOREACTORS -14BCE14

Subject Code	:	14BCE14	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

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.

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.

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.

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.

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.

----------Electives -1----------

TRANSPORT PHENOMENA IN BIOPROCESS SYSTEMS- 14BCE151

Subject Code	:	14BCE151	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

Module 1

EQUATIONS OF CHANGE: Equation of continuity Equation of motion; Navier – Stokes 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 2

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 Requir4ement for sparged and Agitated vessels, 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

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

Module 4

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.

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**

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 -14BCE152

Subject Code	:	14BCE152	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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 1/3rd Rule . Applications: Vapor, Liquid equilibria for binary mixtures, Calculation of Bubble Point Dew point for ideal binary mixture

Module 2

Bioreactor: Operational stages in a Bioprocess industry, biochemical reactor, continuous stirred tank bioreactor-process description, mathematical model, fed-batch bioreactor- model development

Module 3

Design: Double Pipe Heat Exchanger (Area, Length and Pressure drop), Shell & Tube Heat Exchanger (Area, Number of tubes, Pressure drop)

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

Module 5

Mathematical Modeling and Solutions to the Following: Basic tank model – Level V/s time, batch Distillation–Vapour composition with CSTRs in series

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.

FOOD TECHNOLOGY- 14BCE153

Subject Code	:	14BCE153	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

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.

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.

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.

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.

TEXT BOOKS:

1. Rick Parker, **Introduction to Food Science**, Delmar Thomson Learning, 2001.
2. Norman N. Potter and Joseph H. Hotchkin, **Food Science,** 3rd Edition, Springer, 1999.

REFERENCE BOOKS:

1. Subbulakshmi G. and Shobha A. Udupi, **Food Processing and Preservation**, New Age International Pvt. Ltd., 2001.
2. John M deMan, **Principles of Food Chemistry**, 3rd Edition, Aspen Publication, 1999.

ENZYME TECHNOLOGY - 14BCE154

Subject Code	:	14BCE154	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

Module 2

KINETICS:
Chemical mechanisms of enzyme catalysed reactions, introduction to bioenergetics and kinetics, kinetics of multi-substrate bioreactions, investigations of active sites structures.

Module 3

CHEMICAL NATURE OF ENZYME CATALYSIS:
Sigmoidal kinetics and allosteric enzymes, co-enzymes, significance of sigmoidal behaviour.

Module 4

APPLICATIONS:
Investigation of enzymes in biological preparation, extraction and purification, enzymes as analytical reagents

Module 5

INSTRUMENTAL TECHNIQUES:
Instrumental techniques available for using enzymatic analysis, applications in medicine, industries, and biotechnological applications

TEXT BOOKS:

1. Trevor Palmer, "**Understanding Enzymes**"-4th edition, Prentice Hall, 1991.

REFERENCES

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.
3. Nicholas C. Price and Lewis Steven, **Fundamentals of Enzymology** Oxford University Press. Third edition.1999

LABORATORY COMPONENT: 14BCE16

Subject Code	:	14BCE16	IA Marks	:	25
Exam hours	:	02	Final Exam Marks	:	50

Note: Any five experiments

List of Experiments

1. Single Tank – Step response
2. Interacting tanks- Impulse & Pulse Response
3. Non-Interacting tanks- Step Response
4. P, PI and PID controller for valve characteristics
5. Electrophoresis
6. Aqueous two phase extraction
7. Leaf filter
8. Plate and frame filter

SEMINAR-I-14BCE17

Subject Code	:	14BCE17	IA Marks	:	25

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

SECOND SEMESTER M TECH – BIOCHEMICAL ENGINEERING

STATISTICAL METHODS - 14BCE21

Subject Code	:	14BCE21	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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).

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.

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.

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-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.

REFERENCE 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

SAFETY MANAGEMENT IN BIO PROCESS INDUSTRIES - 14BCE22

Subject Code	:	14BCE22	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total Lecture Hours	:	52	Exam Marks	:	100

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, public vs. private funding, biotechnology in international relations, globalization and development divide. Public acceptance issues for biotechnology: Case studies/experiences from developing and developed countries. Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries.

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.

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.

Module 4

REGULATIONS
Biosafety assessment procedures in India and abroad. International dimensions in biosafety: Catagena protocol on biosafety, bioterrorism and convention on biological weapons. Biosafety regulations and national and international guidelines with regard to rDNA technology, transgenic science, GM crops, etc. Experimental protocol approvals, levels of containment. Guidelines for research in transgenic plants. Good manufacturing practice and Good lab practices (GMP and GLP).

Module 5

FOOD SAFETY

The GM-food debate and biosafety assessment procedures for biotech foods & related products, including transgenic food crops, case studies of relevance. Environmental aspects of biotech applications. Use of genetically modified organisms and their release in environment.

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.

TEXT BOOK

1. Thomas JA and Fuch RI (2002) **Biotechnology and safety assessment**, Academic press 2002.
2. Fleming DA and Hunt DL., **Biological Safety principles and practices**, ASM Press 2000.

REFERENCE

1. Lees F.P, Loss Prevention in Process Industries, 2nd Edition, Butterworth Heinemann, 1996.
2. Patterson D, Techniques of safety managements, McGraw Hill, 1978.
3. Handley W., Industrial Safety hand book, 2nd Edition, McGraw Hill, 1977.
4. Levine S.P and Martin, Protecting personnel at hazardous waste sites, Butterworth, 1985
5. Blake R.P., Industrial Safety, Prentice Hall, 1953.

CHEMICAL AND BIOCHEMICAL REACTIONS - 14BCE23

Subject Code	:	**14BCE23**	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

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.

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.

Module 4

INTERNAL TRANSPORT PROCESSES IN POROUS CATALYSTS:
Intra pellet mass and heat transfer, Evaluation of effectiveness factor, mass and heat transfer with reaction.

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, Trickle bed reactor model.

TEXT BOOKS:

1. John Villadsen, Jens Nielsen, Gunnar Lidén, Bioreaction Engineering Principles, Springer Science & Business Media, 2011
2. 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.
3. Fogler H.S, Elements of Chemical Reaction Engineering, Prentice Hall, 1991.

BIOREACTOR DESIGN -14BCE24

Subject Code	:	14BCE24	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	50	Exam Marks	:	100

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.

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

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

Module 4

DESIGN OF VESSEL CLOSURES:
Various Vessel closures such as Flat plates or covers formed, torispherical, elliptical, hemispherical and cylindrical designs. Numerical problems

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.

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

----------Electives -2----------

TOTAL QUALITY MANAGEMENT -14BCE251

Subject Code	:	14BCE251	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

Module 1

CONCEPTS OF TQM:Basics of total quality, Guru's of TQM, Philosophy of TQM, customer focus, organization, quality philosophies of Deming, Crossby.

Module 2

TQM PROCESS: QC tools, problem solving methodologies, cost of quality, quality circles, bench marking, strategic quality planning.

Module 3

TQM SYSTEMS: Quality policy deployment, quality function deployment, standardization, designing for quality, manufacturing for quality.

Module 4

QUALITY SYSTEM: Need for ISO 9000 system, advantages, clauses of ISO 9000, Implementation of ISO 9000, quality auditing, case studies.

Module 5

IMPLEMENTATION OF TQM: KAIZEN, 5s, JIT, POKAYOKE, Taguchi methods, case studies.

TEXT BOOK

1. **Dale H. Besterfield, Total Quality Management, PHI, India.**
2. **Rose, J.E, Total Quality Management, Kogan Page Ltd. 1993.**
3. **John Bank., The essence of total quality management, PHI, 1993.**
4. **Greg Bonds *et al,* Beyond Total Quality Management, McGraw-Hill, 1994.**

NANOTECHNOLOGY AND ITS APPLICATION IN BIOPROCESS INDUSTRIES -14BCE252

Subject Code	:	14BCE252	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

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: Carbon molecule, Clusters, Carbon nanotubes, Applications. Bulk nanostructured materials: Solid disordered nanostructures, nanostructure crystals

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.

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 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.

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 -14BCE253

Subject Code	:	14BCE253	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

Module 1

INTRODUCTION: A historical perspective; Definition and Expanding Needs of Biosensors; Advantages and limitations; Biosensor Economics; various components of biosensors

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

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

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

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.

REFERENCE BOOKS

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

BIOPROCESS MODELING AND SIMULATION -14BCE254

Subject Code	:	14BCE254	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

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.

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.

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.

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.

TEXT BOOKS

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
4.

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

LABORATORY COMPONENT: 14BCE26

Subject Code	:	14BCE26	IA Marks	:	25
Exam hours	:	02	Final Exam Marks	:	50

Note: Any five experiments

List of Experiments

1. Identification of microorganisms using Shake flask reactor
2. Vacuum Distillation
3. BOD and COD analysis
4. Coagulation Jar Test
5. RTD study in plug flow reactor and Chemostat
6. Effect of concentration on enzyme activity
7. Effect of Temperature on enzyme activity

SEMINAR-II -14BCE27

Subject Code	:	14BCE27	IA Marks	:	25

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

THIRD SEMESTER M.TECH – BIOCHEMICAL ENGINEERING

SEMINAR ON INTERNSHIP -14BCE31

Subject Code	:	14BCE31	IA Marks	:	25

The students are required to give a presentation on any INTERNSHIP in the form of seminar after 8 weeks from the date of commencement. The seminar shall be evaluated as internal assessment by a committee constituted by the HoD

REPORT ON INTERSHIP -14BCE32

Subject Code	:	14BCE32	Exam Marks	:	75

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**.**

EVALUATION AND VIVA-VOCE -14BCE33

Subject Code	:	14BCE33	Exam Marks	:	50

The students are required to give a presentation on any INTERNSHIP in the form of seminar. The seminar shall be evaluated.

FOURTH SEMESTER M TECH – BIOCHEMICAL ENGINEERING

BIOENERGY -14BCE41

Subject Code	:	14BCE41	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

Module 1

BIOENERGETICS: Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification. – Chemical composition and properties of different biomass materials and bio-fuels – Sugar cane molasses and other sources for fermentation ethanol-Sources and processing of oils and fats for liquid fuels- Energy plantations -Preparation of woody biomass: Size reduction, Briquetting of loose biomass, Drying, Storage and Handling of Biomass, hydrogen production and biological fuel cell

Module 2

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.

Module 3

BIO-ETHANOL AND BIO-DIESEL TECHNOLOGY: Production of Fuel Ethanol By Fermentation Of Sugars. Gasohol as a Substitute for Leaded Petrol. - Trans-Esterification of Oils to Produce Bio-Diesel.

Module 4

PYROLYSIS AND GASIFICATION OF BIOMASS: Thermo-chemical conversion of ligno-cellulose biomass – Biomass processing for liquid fuel production - 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.

Module 5

COMBUSTION OF BIOMASS AND COGENERATION SYSTEMS: Combustion Of Woody Biomass: Theory, Calculations And Design Of Equipments. Cogeneration In Biomass Processing Industries. Case Studies: Combustion of Rice Husk, Use of Bagasse for Cogeneration.

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.

----------Electives -3----------

BIOLOGICAL WASTE TREATMENT AND ENGINEERING -14BCE421

Subject Code	:	14BCE421	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total Lecture Hours	:	52	Exam Marks	:	100

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

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.

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).

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

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.

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.

BIOLOGICAL THERMODYNAMICS-14BCE422

Subject Code	:	14BCE422	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total Lecture Hours	:	52	Exam Marks	:	100

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.

Module 2

FUNDAMENTAL CONCEPTS OF THERMODYNAMICS: System and Surroundings, First law of thermodynamics -Internal energy, enthalpy, Heat capacity, applied examples from biochemistry.

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.

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.

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.

TEXT BOOK

1. Donald T. Haynie, *Biological Thermodynamics*, Cambridge press, 2008.
2. Robert A. Alberty, *Thermodynamics of Biochemical Reactions*, John willy publications, 2003.

FERMENTATION TECHNOLOGY 14BCE423

Subject Code	:	14BCE423	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

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.

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

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 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;

TEXT BOOK

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

REFERENCE BOOKS:

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

ANIMAL CELL CULTURE & TISSUE ENGINEERING -14BCE424

Subject Code	:	14BCE424	IA Marks	:	50
No of Lecture Hrs/Week	:	04	Exam hours	:	03
Total No.of Lecture Hours	:	52	Exam Marks	:	100

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.

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.

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.

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.

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.

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 I - 14BCE43

Subject Code	:	14BCE43	IA Marks	:	25

EVALUVATION PROJECT PHASE II - 14BCE44

Subject Code	:	14BCE44	IA Marks	:	25

EVALUVATION PROJECT WORK AND VIVA VOCE - 14BCE45

Subject Code	:	14BCE45	IA Marks	:	-
Exam hours	:	03	Exam Marks	:	100+100

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 VTU.