UNIVERSITY OF KERALA

B. TECH. DEGREE COURSE

(2013 SCHEME)

SYLLABUS FOR

VII SEMESTER

BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING

SCHEME -2013

VII SEMESTER

BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING (B)

Course No	Name of subject	Credits	Weekly load, hours			C A Marks	Exam Duration Hrs	U E Max Marks	Total Marks
			L	T	D/P				
13.701	Process Dynamics & Control (B)	4	2	2	-	50	3	100	150
13.702	Bioinformatics (B)	3	2	1	-	50	3	100	150
13.703	Bioprocess Instrumentation (B)	3	2	1	-	50	3	100	150
13.704	Design of Biological Waste Treatment Systems (B)	4	2	2	-	50	3	100	150
13.705	ELECTIVE II	3	2	1	-	50	3	100	150
13.706	Reaction Engineering & Process Control Laboratory (B)	3	-	-	3	50	4	100	150
13.707	Downstream Processing laboratory (B)	3	-	-	3	50	4	100	150
13.708	Mini Project (B)	3	-	-	3	50		100	150
13.709	Seminar, Industrial Visits (B)	3	-	-	3	100			100
	Total	**29**	**10**	**7**	**12**	**500**		**800**	**1300**

13.705 Elective II

13.705.1	Biostatistics (B)
13.705.2	Ethics and Intellectual Property Rights (B)
13.705.3	Bioprocess Plant safety and Hazard Assessment (B)
13.705.4	Biocatalysts and Catalysis (B)
13.705.5	Computational Fluid Dynamics (B)
13.705.6	Drug Design, Development and Manufacture (B)

13.701 PROCESS DYNAMICS AND CONTROL (B)

Teaching Scheme: 2(L) - 2(T) - 0(P) **Credits**: 4

Course Objective:

Considered a premier subject in engineering, process dynamics and control has a true interdisciplinary character, with applications in several sectors of human endeavour. The present course shall however be presented with focus mainly on its applications in process engineering.

Module – I

Introduction to process control concepts: Introduction with a suitable example to bring out concepts like *feedback control*, *feedforward control*, *negative feedback* and *positive feedback*. Importance of study of dynamics for control purpose. Generalized objectives of chemical process control: Illustrative examples to show how the effect of external disturbances are suppressed, how a process is stabilized and how an optimization of the overall performance is carried out.

Classification of variables in a chemical process. Typical design elements of a control system. Control aspects of a complete chemical plant. A brief study of various hardware elements of a typical control system. Sensors for measuring devices. Sensors for flow, pressure, temperature, composition etc. Transmission lines. Final control elements. Use of digital computers in process control.

Development of a mathematical model for control purposes: State variables and state equations of chemical processes. Transport rate equations, kinetic rate equations, reaction and phase equilibria relationships, equations of state. Dead time. Mathematical models of CSTR. mixing process, tubular heat exchangers and binary distillation columns. Input-output models of stirred –tank- heaters, mixing processes and such physical systems. Degrees of freedom and process controllers. Linearization of nonlinear systems (systems with one and two variables). Deviation variables. Linearization of nonisothermal CSTRs. Introduction to state space models concepts. State space model development of simple dynamic systems.

Laplace Transforms and Transfer Functions: Definition of Laplace Transforms (LT). LT of the following: exponential, trigonometric, step, pulse, impulse and translated functions, derivatives and integrals. Initial value theorem, final value theorem. Inversion of Laplace Transforms. Methods of solving Ordinary Linear Differential Equations (OLDE) by using LT. Examples. Transfer functions of systems with single input. Transfer function matrices of systems with multiple outputs. Development of the transfer function matrix for a CSTR. Representation of transfer functions with block diagrams. Block diagram algebra. Poles and Zeros of transfer functions. Qualitative nature of response of dynamical systems.

Module – II

Dynamic behaviour of Low Order Systems and Pure delay Systems: Dynamic systems with a capacity for mass storage and energy storage, Pure capacitive process, Response of pure capacitive process, Dynamic response of first order lag system. Effect of parameters on the response of a first order system. First order systems with variable time constants and gain. Second order systems. Damping factor/coefficient. Underdamped, critically damped and overdamped responses. Characteristics of standard underdamped dynamic systems used as a measure of performance. Approximation of multicapacity process with second order models. Interacting and noninteracting capacities in series with examples. Manometer dynamics. Dynamics of tanks -in –series liquid level systems. N capacities in series. Jacketed heat exchange vessels. Systems with dead time. Systems with inverse response.

Module – III

Analysis of Feedback Control Systems: Types of feedback controllers, Proportional (P), Proportional Integral (PI) and Proportional Integral Derivative (PID) type of controllers. Parameters of PID type controllers. Block diagrams and closed loop responses. Closed loop response of the liquid level in a tank. Closed loop temperature response of a tank heater. Effect of proportional, integral and derivative control actions on the response of a controlled process. Effect of composite control actions.

Stability analysis of Feedback Systems: The notion of stability, Characteristic equation, Routh-Hurwitz criterion for stability. Root locus analysis. Frequency response, Bode stability criterion, Bode diagrams, Nyquist stability criterion, Nyquist plots. Frequency response of closed loop systems.

Module – IV

Design of Feedback Controllers: Outline of the design problems. Simple Performance criteria, Time-integral performance criteria, Selection of type of feedback controllers. Design of Feedback Controllers by Frequency Response Techniques. Gain and Phase margins, Controller tuning, Zeigler – Nichols Tuning technique, Cohen and Coon tuning method.

A brief introduction to advanced control systems. Only familiarity of the terms like *dead-time compensation, cascade control, selective control, split –range control, feed forward control, ratio control, adaptive control, inferential control, distributed control, direct digital control and supervisory control*. Concept of discretization and Z-transformsfusion.

References:

1. George Stephanopoulos, *Chemical Process Control, An Introduction to Theory and Practice*, Prentice Hall of India, New Delhi, 1999.
2. Coughnowr, *Process Systems Analysis and Control*, McGraw Hill, Singapore, Second Edition, 1991.
3. Luyben W. L., *Process Modeling, Simulation and Control for Chemical Engineers*, McGraw Hill Singapore, 1990.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from Module- I and II and two questions each from module- III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Note: *Part B questions should have at least 60 % numerical problems. There could be numerical problems in part A also.*

Course Outcome:

The course shall serve as a strong foundation for engineering undergraduates who aspire to take up higher studies or a promising career in process control or control systems engineering. It shall however, be particularly suited to fulfill the needs of the process industry.

13.702 BIOINFORMATICS (B)

Teaching Scheme: 2(L) - 1(T) - 0(P) **Credits**: 3

Course objectives:

'Dry lab' or 'in-silico' analysis has revolutionized the biotechnology sector over the past few years. Metagenomics research, genome projects and genetic level characterization studies are highly dependent on bioinformatics, which is a merger of biology with information technology. The course is aimed at providing a theoretical background on bioinformatics, with an overview of the tools, techniques and applications of the discipline in biotechnology.

Module – I

Introduction to Genomic data and Data Organization: Sequence Data Banks – Introduction to sequence data banks – protein sequence data bank. NBFR-PIR, SWISSPROT, Signal peptide data bank, Nucleic acid sequence data bank – GenBank, EMBL nucleotide sequence data bank, AIDS virus sequence data bank. rRNA data bank, structural data banks – protein Data Bank (PDB), The Cambridge Structural Database (CSD) - Genome data bank – Metabolic pathway data -Microbial and Cellular Data Banks.

Module – II

Introduction to MSDN (Microbial Strain Data Network): Numerical Coding Systems of Microbes, Hybridoma Data Bank Structure, Virus Information System, Cell line information system- other important Data banks in the area of Biotechnology/life sciences/biodiversity. Sequence analysis: Analysis Tools for Sequence Data Banks; Pair wise alignment - Needleman and Wunsch algorithm, Smith Waterman algorithm, BLAST, FASTA algorithms to analyze sequence data- Sequence patterns motifs and profiles.

Module – III

Secondary and Tertiary Structure predictions; prediction algorithms; Chao-Fasman algorithm, Hidden Markov model, Neural Networking.

Electrokinetic separations: Electrophoresis – Principles and techniques- immunoelectrophoresis, capillary zone electrophoresis - isoelectric focusing, isotachophoresis.

Module – IV

Applications in Biotechnology: Protein classifications, Fold libraries, Protein structure prediction: Fold recognition (threading), Protein structure predictions: Comparative

modeling (Homology), Advanced topics: Protein folding, Protein-ligand interactions, Molecular Modeling and Dynamics, Drug Designing.

References

1. Lesk, *Introduction to Bioinformatics*, Oxford University Press
2. Cynthia Gibas and Per Jambeck, *Developing Bioinformatics Computer Skills,* SPD, 2001.
3. Atwood*, Introduction to Bioinformatics,* Pearson Education
4. Tisdall, *Beginning Perl for Bio-informatics,* SPD
5. Smith D.W*, Biocomputing: Informatics and Genome Project,* Academic Press, NY, 1994.
6. Baxevanis A.D, B.F.F. Quellette, *Bioinformatics: A practical Guide to the Analysis of Genes and Proteins,* John Wiley and Sons.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours Maximum Total Marks: 100

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course outcome:

Upon successful completion of this course, the students should have grasped the fundamentals of in silico analysis and its applications in Biotechnology. With adequate supplementary hands- on training, they should be able find their way towards a rewarding career in bioinformatics.

13.703 BIOPROCESS INSTRUMENTATION (B)

Teaching Scheme: 2(L) - 1(T) - 0(P) **Credits**: 3

Course objectives:

This course aims at providing an overall picture of the various instrumental techniques used in process industries for measurement applications. The course should be delivered with proper emphasis on the principles, operation and applications of each measuring device. Supplementary teaching aids shall be used to impart a clear understanding of the specific industrial situations which employ theses devices.

Module – I

Basic principles of measurements - Classification methods of measurements - Direct and indirect measurements, various elements in a measuring instrument - Sensing element, transducing element manipulating element and functioning element etc- Principles of working with a suitable example, static and dynamic characteristics of measuring instrument, accuracy, reproducibility, sensitivity, static error, dead zone, dynamic error, fidelity lag, speed of response etc.

Sensing elements - various types of sensing elements, sensors for temperature, pressure and fluid flow, transducers, different types of transducers, their principles and working, transmission methods, indicating and recording means.

Temperature measurements, temperature scales, basic principles and working of thermometers, mercury in glass thermometers, resistance thermometers, thermocouples, optical pyrometers, radiant pyrometers, ranges of different types of temperature measuring instruments, sources of errors and precautions to be taken in temperature measurements.

Module – II

Pressure measurement - Principles of working of manometers, various types of manometers- Macleoad gauge, Kundsen gauge, Bourden gauge, bellows, diaphram, electrical pressure transducers peizo electric manometers, thermal conductivity guages- ionization guage high pressure measuring instrument, liquid level measurements - Sensitive measurements, conductivity meters, measurements of PH.

Module – III

Flow measurements - Liquid and gas flow measurements, ways of measuring liquids and gas flow, direct volume measurements, quantity meters, gas meters, magnetic flow meters, heat input flow meters, elbow flow meters, impact meters, variable area meters, rotameters, cylinder and piston type - Liquid flow velocity, turbine meters, open channel flow measurements, wires notches, head meters, pitot tube, orifice meters ventury meters, theory and working flow measurements, electrical transducers, turbine type flow meters strain gauge flow meters mass flow meter, measuring flow of dry materials.

Module – IV

Thermal analysis - Differential thermal analysis, thermo gravimetric, conductimetric analysis Chromatography and application, developments of P&I, diagram for flow systems, level, PH control temp control, Heat exchangers, Distillation column, reaction system etc.

References:

1. Eckman D. P., Industrial instrumentation, Wiley Eastern.
2. Fribance, *Industrial Instrumentation Fundamentals*, Tata McGraw Hill.
3. Jain R.K., Mechanical and industrial measurements, Khanna Publication.
4. Patranabis, *Principles of industrial Instrumentation* , Tata McGraw Hill.
5. Beckwith and Buck, *Measurement Systems*

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.
20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours Maximum Total Marks: 100

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course Outcome:

This course shall offer a clear understanding on the applications of instrumental techniques for analysis and measurements in the process industry. With modest level of supplementary hands-on-training, any successful student should become competent at handling measuring devices for various industrial applications in their future career.

13.704 DESIGN OF BIOLOGICAL WASTE TREATMENT SYSTEMS (B)

Teaching Scheme: 2(L) - 2(T) - 0(P) **Credits**: 4

Course objectives:

With rapidly growing human populations, disposal of wastes has become a global problem. Several newer technologies for waste treatment have been developed, which if suitably designed and applied shall be of substantial benefit to the society. The present course aims at providing the complete theoretical background necessary for the design of biological waste treatment systems for various industrial, agricultural and domestic situations.

Module – I

Wastewater characteristics: composition and microbiology of wastewater, Mathematical modeling of BOD, kinetics. Wastewater treatment: Basic design consideration, principles of reactor design and process flow sheets.

Objectives and fundamentals of biological treatment, types of biological treatment processes. Conventional activated sludge process, process kinetics and design considerations, process control measures, operational problems. Design of aerobic suspended growth systems including activated sludge process (Activated sludge process and its modifications, Integrated design procedure, design and control parameters, applications)and aerated lagoon.

Biological Nitrogen Removal, Biological Phosphorous Removal.

Module – II

Trickling filter: Classification- standard and high rate, Principles of design, process design considerations, construction and design of oxidation ponds, aerobic sludge digestion, theory and design of waste stabilization ponds and oxidation ditches, factors affecting the design, design of digestion tank, septic tanks: working principles and design, soak pits. Biosorption contact stabilization. Biological film flow processes - Sanitation land fill - Municipal and compost treatment - Predigestion of waste. Theory and design of aerobic attached growth systems including rotating biological contactor.

Module – III

Fundamentals of anaerobic treatment, types, Anaerobic lagoons - Anaerobic digestion - contact and filter digestion - Energy production by digester and Non homogeneous reactions - reactors – physical and chemical removal of dissolved materials - Gas transfer - mass models - Bubble aeration - film flow oxygen transfer - stripping - solids removal. Discrete particle - sedimentation and thickening.

General design considerations, of anaerobic reactors. Anaerobic sludge blanket processes, Design considerations for Up flow Anaerobic Sludge Blanket process and hybrid reactors. Theory and design of Sludge treatment, sludge thickening, sludge drying, incineration, aerobic and anaerobic digestion of sludge. Sewage treatment plant layout, concept of sustainable wastewater treatment.

Module – IV

Biogas Technology: Worldwide perspective of anaerobic digestion, Review of anaerobic digestors, Realistic potential of biogas plant installation, Problems encountered in the installed plants, Analysis of biogas systems, Optimising the prospects of different designs of biogas plants, Engineering design of fixed dome type - continuous type plants - semi continuous plants, Microbiology of biogas production, Methods to enhance the biogas production, Design parameters affecting the success and failure of biogas plants, Structural behaviour and stress conditions in fixed dome biogas plant, Structural behaviour and stress conditions in KVIC plant, Performance of different types of gas holders, Alternate constructions material for biogas plant construction, Various techniques for increasing gas production in cold region.

Effect of heating , insulation and stirring on gas production, Design optimization for biogas production, Multi criteria optimization, Immobilisation biogas plant system – principle, Application of immobilization, Modular biogas systems for tropical areas – principle, Prospects of modular biogas systems, Alternate feedstock for biogas production

Effect of pesticides on anaerobic digestion, Effect of herbicide on anaerobic digestion, Kinetic models for predicting biogas production, Monod kinetics and related studies, Determination of kinetic parameters, Design equations of biogas plants.

References:

1. Marcos Von Sperling, *Waste Water Characteristics, Treatment and Disposal, Biological Waste Water Treatment, Serie I,* Iwa Publishing (Intl water Association), 2007
2. Manual on Sewerage and Sewage Treatment, C.P. H.E. E. O, Ministry of Urban Development, Government of India, New Delhi
3. Tchbanoglous and F.L. Burton, *Metcalf and Eddy's Wastewater Treatment-isposal And Reuse (Third Ed.),* TMH publishing Co Ltd, N. Delhi. (1996)
4. Howard S. Peavy, Donald R. Rowe and George Techobanoglous: *Environmental Engineering,* McGraw- Hill
5. Reynolds T.D and Richards P.A, *Unit Operations and Processes in Environmental Engineering*, PWS, 1996.
6. Viessman W. and Hammer M. J, *Water Supply and Pollution Control,* 7th Edition, Harper Collins, 2004.
7. Rittmann and McCarty, *Environmental Biotechnology* 1st Edition, McGraw-Hill, 2001
8. Grady Jr. C. P. L., Daigger G. T. and Lim H. C, *Biological Wastewater Treatment*. 2nd Ed., Revised and Expanded, Marcel Dekker, Inc., New York, 1999.

9. Santhosh Kumar Garg, *Sewage Disposal and Air Pollution Engineering,* Khanna Publishers.
10. Syed R. Qasim and Sayeed R. Qasim, *Wastewater Treatments: Planning, Design and Operation*, CRC Press, 1998
11. Parker, *Wastewater Systems Engineering,* CBS Publishers
12. Mark J. Hammer and Mark J. Hammer Jr., *Water and Wastewater Technology,* Prentice Hall of India
13. Sincero and Sincero, *Environmental Engineering: A Design Approach,* Prentice Hall of India
14. Rao C.S, *Environmental Pollution Control Engineering*, Wiley 2nd Edition, New Age International Publishers, 2006.
15. Mahajan S.P, *Pollution Control in Process Industries*, Tata McGraw Hill, New Delhi, 1985
16. Vogt,P, *Energy conservation and use of Renewable Energies in the Bio-industries.*
17. Nejat Veziroglu, T, *Alternate Energy sources Vol IV*. Ann Arbor Science, London, 1982. .
18. Halwagi, *Biogas Technology - Transfer and Diffusion.* MNES Publication.
19. Chawla, O.P, *Advances in Biogas technology.*
20. Leslie Grady, C.P and Henry C. Lim, *Biological waste water treatment,* Marcel Dekker, Inc. New York, 1980.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course Outcome:

Upon successful completion of this course, students shall be equipped with the necessary theoretical background, tools and techniques to design waste treatment systems for domestic and industrial applications, which shall enable them to fulfil their societal commitment, while at the same time pursuing a rewarding professional career.

13.705.1 BIOSTATISTICS (B) (Elective II)

Teaching Scheme: 2(L) - 1(T) - 0(P) **Credits**: 3

Course Objectives:

This course is mandatory for students who aspire to take up a research career in Biotechnology. Techniques for statistical analysis and their applications in research shall be clearly explicated, with adequate emphasis on case studies and examples drawn primarily from biological sciences.

Module – I

Presentation of Data: Frequency distribution, graphical presentation of data by histogram, frequency curve and cumulative frequency curves. Applications of statistics in biological sciences and genetics.

Descriptive statistics; Mean; Variance; Standard deviation and coefficient of variation (CV); Comparison of two CVs; Skewness; Kurtosis Probability – axiomatic definition; Addition theorem; Conditional probability; Bayes theorem; Random variable; Mathematical expectation. Theoretical distributions– Binomial, Poisson, Normal, Standard normal and Exponential distributions; Sampling- parameter, statistic and standard error; Census – sampling methods; Probability and non- Probability sampling; Purposive sampling; Simple random sampling; Stratified sampling.

Module – II

Testing of hypothesis; Null and alternative hypothesis; Type I and type II errors; Level of significance; Large sample tests; Test of significance of single and two sample means; Testing of single and two proportions - Small sample tests: F-test – testing of single mean; Testing of two sample means using independent t test, paired t test; Chi square test: Test for goodness of fit – association of attributes – testing linkage – segregation ratio.

Module – III

Correlation – Pearson's correlation coefficient and Spearman's rank correlation; Partial and multiple correlation –
regression analysis; Sample linear and non linear regression; Multiple regression.

Module – IV

Experimental Designs: Principles of experimental designs, Completely randomized, Randomized block and latin square designs, Simple factorial experiments of 22, 23, 24 and 32 types, Analysis of variance – definition – assumptions – model; One way analysis of variance with equal and unequal replications; Two way analysis of variance; Non parametric tests – sign test – Mann Whitney 'U' test – Kruskal Wallis test.

References:

1. Sundar Rao P.S.S, Richard P.H, Richard J., *An introduction to Biostatistics,* Prentice Hall of India (P) Ltd, New Delhi, 2003.
2. Rangaswamy R*, A text book of Agricultural Statistics,* New Age International (P) Ltd., New Delhi, 2000
3. Gupta S.P, *Statistical Methods*, Sultan Chand and Sons, New Delhi. 2005.
4. Panse V.G.Panse, Sukhatme P.V, *Statistical methods for Agricultural Workers,* ICAR Publications, New Delhi, 2000
5. Jerrold H. Zar, *Bio Statistical Analysis*, Tan Prints (I) Pvt. Ltd., New Delhi, 2003.
6. Chandel S.R.S, *A Hand Book of Agricultural Statistics*, Achal Prakashan Mandir, Kanpur, 1999.
7. Norman T.J. Bailey, Statistical *methods in biology,* (3rd Edition, Cambridge University Press, 1995.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.
20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours Maximum Total Marks: 100

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

***Note:** Part B questions should have at least 60 % numerical problems. There could be numerical problems in part A also.*

Course outcome:

Upon successful completion of this course, students shall be equipped with the necessary theoretical as well as applied knowledge on the statistical analysis in bio-sciences research. This shall enable them to pursue independent research on target areas which they could choose in the course of their future endeavour.

13.705.2 ETHICS AND INTELLECTUAL PROPERTY RIGHTS (B) (Elective II)

Teaching Scheme: 2(L) - 1(T) - 0(P) **Credits**: 3

Course Objectives:

This course shall provide an overview of the ethical issues associated with scientific research and practice in biotechnology. It shall also deal at depth about the critical aspects of Intellectual property rights and the relevant guidelines and regulations pertaining to protection of IPR.

Module – I

Biosafety and Bioethics: Bioethics: Social and ethical issues in Biotechnology, Legality, morality and ethics, the principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity etc. Ethical considerations in genetic engineering, Ethics in genetic testing and screening, medical safety, Legal implications and public concerns in Human gene therapy, genetic modifications and food uses.

Biotechnology and Bioethics: The expanding scope of ethics from biomedical practice to biotechnology, ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, bioethics vs. business ethics, ethical dimensions of IPR, technology transfer and other global biotech issues.

Module – II

Application in clinical trial management; Risk assessment; Research ethics and Bioethics - Principles of research ethics; Ethical issues in clinical trials; Use of humans in Scientific Experiments; Ethical committee system including a historical overview; the informed consent; Introduction to ethical codes and conduct; Introduction to animal ethics;

Animal rights and use of animals in the advancement of medical technology; Introduction to laws and regulation regarding use of animals in research.

Intellectual property rights in Biotechnology: WTO as an international agency controlling trade among nations. WTO with reference to biotechnological affairs, TRIPs. Juriprudential definition and concept of property, rights, duties and their correlation; History and evaluation of IPR – like patent design and copyright. Patent claims, the legal decision – making process, ownership of tangible and intellectual property.

Module – III

Basic Requirements of Patentability Patentable subject matter, novelty and the public domain, non obviousness.

Special issues in Biotechnology Patents Disclosure requirements, Collaborative research, Competitive research, Plant biotechnology: Indian patents and Foreign patents, Plant variety protection act, The strategy of protecting plants.

Patent Litigation Substaritive aspects of patent litigation, Procedural aspects of patent litigation, different Doctrines. Recent Developments in Patent System and Patentability of biotechnological inventions.

Module – IV

IPR issues in Indian Context: Intellectual property rights and Intellectual Property protection, patents and methods of application of patents, Trade Secrets copyrights, Trade Marks, legal implications, farmers rights, plant breeder's rights. International and National conventions on biotechnology and related areas. Role of patent in pharmaceutical industry, computer related innovations

Case studies Rice, Haldi, Neem, etc. and challenges aheadand cephalosporin, fermentation process, extraction and purification. Cancer immunotherapy.

References:

1. Thomas, J.A., Fuch, R.L. *Biotechnology and Safety Assessment* (3rd Ed), Academic Press, 2002.
2. Fleming, D.A., Hunt, D.L, *Biological safety Principles and practices* (3rd Ed). ASM Press, Washington.
3. Sibley, *The law and strategy of Biotechnological patents,* Butterworth publications.
4. Ganguli, *Intellectual Property Rights,* Tata McGrawhill
5. Wattal, *Intellectual Property Rights*, Oxford Publishing House.
6. Smith J.E, *Biotechnology, 3rd edition*, Cambridge Univ. Press, 1996.
7. Santaniello, Evenson, Ziberman, Carlson, *Agriculture and Intellectual Property Rights,* Univ. Press, 1998.
8. Thackerey,A (ed), *Private Science : Biotechnology and the Rise of the Molecular Sciences,* Univ of Pennsylvania Press, Phil, 1998
9. Singh K, *Intellectual Property Rights on Biotechnology,* BCll, New Delhi.
10. Sasson A, *Biotechnologies and Development,* UNESCO Publications, 1988.

Important Links:

1. http://www.w3.org/IPR/
2. http://www.wipo.int/portal/index.html.en
3. http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html
4. www.patentoffice.nic.in
5. www.iprlawindia.org/ - 31k - Cached - Similar page
6. http://www.cbd.int/biosafety/background.shtml
7. http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm
8. http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section .html

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours Maximum Total Marks: 100

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course outcome:

Following an ethical approach in research practice and applications involving biotechnology is absolutely essential, considering the sensitive nature of public perception about the subject. Knowledge of bioethics and IPR regulations is likely to enable a student who aspires to take up research career in the relevant area, to handle various situations he/she encounters, with adequate caution and care..

13.705.3 BIOPROCESS PLANT SAFETY AND HAZARD ASSESSMENT (B) (Elective II)

Teaching Scheme: 2(L) - 1(T) - 0(P) **Credits**: 3

Course Objectives:

The role of a safety engineer in a process industry is quite significant. Sustained optimal operation of any process plant should always be counterbalanced by the safety considerations. The present course aims at providing a general overview of various safety considerations in process industries, with emphasis on the biotech industries.

Module – I

Safety and Hazard Analysis: Hazards: Chemical hazards classification, Radiation hazards and control of exposure to radiation. Types of fire, Fire prevention methods:- Chemistry of fire; Production of fire; fire development; severity and duration; effect of enclosure and heat transfer.

Industrial hygiene; Routes of entry of foreign substance; Long term medical disorders and epidemiology; Stress and the workplace; Industrial noise; Hazardous waste. Mechanical hazards. Electrical hazards.

Pyschology and Hygiene: Industrial psychology and Industrial hygiene: Safety in plant site selection and plant layout.

Industrial lighting and ventilation. Industrial noise. Occupational diseases and control: Occupational diseases and prevention methods. Safe housekeeping instrumentation for safe operation. Personal protective equipments. Safety in chemical operations and processes.

Module – II

Hazard: Identification; Occupational hazard; Preliminary hazard analysis; Hazard and operability review (HAZOP). Hazard control: Engineering and management controls; Fault tree analysis; Risk analysis and management.

Case studies of safety and hazard assessment in different industries; Disaster management planning; Insurance tariffs in hazardous industries; Design for safety, maintenance and fault diagnosis.

Module – III

RISK ANALYSIS and HAZOPS: A brief introduction to Consequence Analysis - Dispersion and Toxic models: Risk analysis: Introduction, Rapid risk analysis, Comprehensive risk analysis -

Failure types and release rate calculation - Emission and dispersion - Dispersion models for dense gas – Plume dispersion - Jet dispersion – Toxic dispersion model - Evaluation of risk contours.

Module – IV

Biosafety: Introduction; historical backround; Biosafety in the laboratory/institution: Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution. Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and infected Animals;

Biosafety guidelines: Government of India guide lines; Definition of Genetically modified Organisms (GMOs) and

Living Modified Organisms (LMOs); Roles of Institutional Biosafety Committee, RCGM, Genetic Engineering

Approval Committee (GEAC) etc. for GMO applications in food and agriculture; biosafety assessment procedures for biotech foods and related products, including transgenic food crops, case studies of relevance.

Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National regulations and relevant International Agreements including Cartegana Protocol on biosafety, bioterrorism and convention on biological weapons.

References:

1. Wills, G.L, *Safety in Process Plant Design*, John Wiley and Sons.
2. Frank P. Less, *Loss Prevention in Process Industries, Volume I and II,* Butterworth Heinemann, 1980.
3. Crowl, D.A and Louvar, J.F, *Chemical Process Safety: Fundamentals with Applications,* Prentice Hall, Inc.
4. Pandey, C.G, *Hazards in Chemical Units: a Study*, Oxford IBH Publishing Co., New Delhi.
5. Fawcett H.H and Wood W.S, *Safety and Accident Prevention in Chemical Operation,* 2 Ed, Wiley Interscience, 1982.
6. *Industrial Safety and Laws, by* Indian School of Labour Education, Madras, 1993.
7. Raghavan K. V and Khan A A, *Methodologies in Hazard Identification and Risk Assessment,* Manual by CLRI, 1990.
8. Marshal V. C, *Major Chemical Hazards,* Ellis Horwood Ltd., Chichester, United Kingdom, 1987.
9. *A Guide to Hazard Operability Studies,* Chemical Industry Safety and Health Council of the Chemical Industries Association (London), 1977.

Important Links:

1. http://www.cbd.int/biosafety/background.shtml
2. http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm
3. http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section 3.html

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course outcome:

Upon successful completion of this course, a student should become familiar with all basic aspects of safety in the operation of a bioprocess plant. He/she should be able to contribute effectively in his /her role as a safety engineer, in the course of his/her career in a bioprocess industry.

13.705.4 BIOCATALYSTS AND CATALYSIS (B) (Elective II)

Teaching Scheme: 2(L) - 1(T) - 0(P) **Credits**: 3

Course Objectives:

This course presents the key concepts underlying catalysis in its true biochemical perspective. The mechanisms of various biocatalytic reactions and their applications in specific contexts shall be explicated at depth.

Module – I

Biocatalysis: Definition of biocatalysis; chirality and biological activity- advantages and disadvantages of biocatalysis over chemical catalysis. Different types of biocatalysis- microbial, enyzmatic and immobilized system of biocatalysis; industrial biocatalysis with different enzymes.

Introduction to enzymes: Introduction, Classification, action and specificity, Enzyme stability, monomeric and oligomeric enzymes. Structure of enzymes- X ray crystallography of enzymes, Extraction and Purification of enzymes, control of Enzyme activity.

Multifunctional catalysis and simple models – alpha chymotrypsin - Hydrolytic Enzymes, Stereo electronic control - Immobilised enzymes - Enzymes in synthetic organic chemistry - Design of molecular clefts.

Enzyme kinetics and modeling of enzymatic systems: Kinetics of single substrate, multisubstrate enzyme catalyzed reaction, relation of kinetic parameters, microenvironmetal effects on enzyme kinetics.

Enzyme models: Host guest complexation Chemistry, Developments in Crown ether chemistry, membrane chemistry and micelles - Cyclodextrin - Enzyme design using steroid templates - Remote functionalisation reaction – Biomimetic polyene cyclisations.

Regeneration of co-factors for enzyme biocatalysis: NADP (H) regeneration, ATP/NTP regeneration, sugar nucleotide regeneration, acetyl CoA enzyme regulator etc.

Module – II

Enzyme catalyzed organic synthesis: Introduction, solvent systems, enzyme inactivation in organic solvents, effects on enzyme activity, enzyme formulation in organic media, lymphoid enzyme, absorbed, entrapped etc. and applications-Kinetic resolution, asymmetric synthesis.

Biotransformation with enzymes: Biocatalyst selection, biocatalyst treatment and mode of operation (Immobilization) and application- steroids, terpenes etc. Production of molecules with flavoring properties.

Enzyme as tools for stereo specific c- c bond formation in Monosaccharide and analogues: Enzymes like DHAP aldolase, pyruvate aldolase, tyrosine kinase and their uses,Uses of mutagenesis to increase substrate specificity, Producing catalytic antibodies etc.

Stereoselective biocatalysis for synthesis of chiral pharmaceutical intermediates such as synthesis of ACE inhibitors; definition, mode of action of inhibitors; recent developments, synthesis of anticholesterol drugs by biocatalytic routes, calcium channel blocking drugs, potassium channel openers, antiviral etc.

Module – III

Industrial enzymes: Modes of action and applications of a few industrial enzymes like glucose isomerase, cellulases, pectinases, proteolytic enzymes, carbohydrases, lignocellulose degrading enzymes, lipases, Penicillin acylases, amino acylase, cyclodextrin glycosyl transferase.

Module – IV

Protein Engineering of Industrial enzymes: Targets by Chemo enzymatic Synthesis, rational design methods, site directed mutagenesis, Chemical modification and unnatural amino acids, Random methods like molecular evolution,

DNA shuffling, sequence space, method for mutagenesis, methods for recombination, sequence homology independent recombination, screening and selection.

References:

1. Palmer.T, *Enzymes*, Horwood Publishing Series.2001
2. Price N.C and. Stevens L, Fundamentals *of Enzymology,* Oxford University Press. 2002
3. Branden and Tooze, *Introduction to Proteins Structure Garland*, Publishing Group. 1998
4. Zubay G, Biochemistry*,* Maxwell Macmillan International Editions, Second Edition, 1987.
5. Dugas H, *Bio-Organic Chemistry - A Chemical approach to enzyme action, Springer* Verlag, 1989.
6. Andreas S. Bommarius and Bettina R. Riebel, *Biocatalysis: Fundamentals and Applications,* Wiley VCH, 2004.
7. Lawrence P. Wackett and C. Douglas Hershberger, *Biocatalysis and Biodegradation: Microbial Transformation of Oraganic Compounds,* ASM Press, Washington DC, 2001.
8. Stanley M. Roberts, Nicholas J. Turner, Andrew J. Willets and Michael K. Turner. *Introduction to Biocatalysis: Using Enzymes and Microgansims,* Cambridge University Press, 1995.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours Maximum Total Marks: 100

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course outcome:

The concepts developed from this course are pivotal to many applied areas of biotechnology. It could assist in developing new industrial biocatalysts with improved properties, newer drugs with increased therapeutic effectiveness etc. It shall be of substantial interest to students who aspire to pursue a research oriented career in biocatalytic reaction engineering.

13.705.5 COMPUTATIONAL FLUID DYNAMICS (B) (Elective II)

Teaching Scheme: 2(L) - 1(T) - 0(P) **Credits**: 3

Course Objectives:

Computational fluid dynamics is an advanced subject area, with applications in all fields of engineering. It builds on the principles of momentum transfer (fluid mechanics) and relies significantly on the use of digital computers for solving problems involving momentum transfer. The subject shall be presented initially in a general perspective, with appropriate mention of its applications in the bioprocess industry.

Module – I

Conservation Laws of Fluid Motion and Boundary Conditions: Governing equations of fluid flow and heat transfer,

Equations of state, Navier-Stokes equations for a Newtonian fluid, Classification of physical behaviour, Classification of fluid flow equations, Auxiliary conditions for viscous fluid flow equations.

Turbulence and its Modeling: Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier- Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model, The k-ε model, Reynolds stress equation models, Algebraic stress equation models.

Module – II

The Finite Volume Method for Diffusion Problems: Introduction, one-dimensional steady state diffusion, two dimensional diffusion problems, three-dimensional diffusion problems, discretised equations for diffusion problems.

The Finite Volume Method for Convection-Diffusion Problems: Steady one-dimensional convection and diffusion, The central differencing scheme, Properties of discretisation schemes-Conservativeness, Boundedness, Transportiveness, Assessment of the central differencing scheme for convection-diffusion problems, The upwind differencing scheme, The hybrid differencing scheme, The power-law scheme, Higher order differencing schemes for convection-diffusion, Quadratic upwind differencing scheme. Construction of geometry and discretion using Gambit-Fluent's manuals; Commercial CFD solvers.

Module – III

The Finite Volume Method for Unsteady Flows and Implementation of Boundary Conditions: One-dimensional unsteady heat conduction, Discretisation of transient convection-diffusion

equation, Solution procedures for unsteady flow calculations, Implementation of Inlet, outlet and wall boundary conditions, constant pressure boundary condition. Customizing commercial CFD solver.

Module – IV

Concept of using CFD in bioreactors for the culture of tissue engineered construct (TEC)). A brief outline of the analogous nature of fluid mechanics and nutrient transport. A brief overview of CFD being as a tool for tissue engineers to analyze and visualize the impact of fluidic forces and stresses on cells and TECs. Concept of CFD to study oxygen transfer in Bioreactors.

References:

1. Anderson, J.D, *Computational Fluid Dynamics: The Basics with Application* McGraw Hill Co. Inc.
2. Anderson, D.A, Tannehill, J.C. and Pletcher, R.H., *Computational Fluid Mechanics and Heat Transfer,* Hemisphere Publishing Corporation.
3. Patankar, S.V, *Numerical Heat Transfer and Fluid Flow*, Hemisphere Publishing Corporation.
4. Ferziger, J.H and Peric, M., *Computational Methods for Fluid Dynamics,* Springer.
5. Versteeg, H.K and Malalasekera, W, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method,* Prentice-Hall Inc.
6. Versteeg H. K and MalalasekeraW, *An introduction to computational fluid dynamics: the finite volume method,* Longman scientific and technical publishers, 2007.
7. Vivek V. Ranade, *Computational Flow Modeling for Chemical Reactor* Engineering, Academic Press, San Diego, 2002.
8. H. Singh and D. W. Hutmacher, *Bioreactor Systems for Tissue Engineering,* Springer Berlin/ Heidelberg, 2009.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours Maximum Total Marks: 100

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course outcome:

A knowledge of computational fluid dynamics shall enable students to address various issues relating to fluid flow and mixing in the design of bioreactor systems. This shall help them to contribute effectively as a bioprocess engineer in future.

13.705.6 DRUG DESIGN, DEVELOPMENT AND MANUFACTURE (B) (Elective II)

Teaching Scheme: 2(L) - 1(T) - 0(P) **Credits**: 3

Course Objectives:

This course is aimed at providing an insight into the contemporary techniques in the design, development and manufacture of drugs, particularly biopharmaceuticals. With rapid advances being made in the field of personalized medicine, knowledge of the basic techniques for developing newer drugs to combat ailments is absolutely essential for students who aspire to take up a career in biopharmaceutical technology.

Module – I

Introduction: History of pharmacy; The pharmaceutical industry and development of drugs; Economics and regulatory aspects; Quality management; GMP

Analog Based Drug Design: Introduction to QSAR. lead module, linear and nonlinear modeled equations, biological activities, physicochemical parameter and molecular descriptors, molecular modeling in drug discovery.

Structure Based Drug Design: 3D pharmacophores, molecular docking, De novo Ligand design, Free energies and solvation, electrostatic and non-electrostatic contribution to free energies.

Further applications on the design of new molecules: 3D data base searching and virtual screening, Sources of data, molecular similarity and similarity searching, combinatorial libraries – generation and utility.

Module – II

Drug kinetics and biopharmaceutics: Mechanism of drug absorption, distribution, metabolism and excretion – factors affecting the ADME process; Bioequivalence; Pharmacokinetics.

Drug development and trial planning - pre-study requirements for clinical trials; Regulatory approvals for clinical trials; Consort statement; Trial responsibilities and protocols - roles and responsibilities of investigators, sponsors and others; Requirements of clinical trials protocols; Legislative requirements for investigational medicinal products.

Principles of drug manufacture: Compressed tablets, wet granulation-dry granulation or slugging-direct compression-tablet presses, coating of tablets, capsules, sustained action dosage forms Liquid dosage forms – solutions, suspensions and emulsions; Topical applications – ointments, creams, suppositories; Solid dosage forms – powders, granules,

capsules, Aerosols; Preservation; Packing techniques. analytical methods and test for various drug and pharmaceuticals, quality management, GMP.

Important Unit Processes and their Applications: Bulk drug manufacturers, Type of reactions in bulk drug manufacture and processes. Special requirement for bulk drug manufacture.

Module – III

Pharmaceutical Product and their Control: Therapeutic categories such as vitamins, laxatives, analgesics, nonsteroidal contraceptives, Antibiotics, biologicals, hormones.

Advances in drug delivery: Advanced drug delivery systems – controlled release; Transdermals, Liposomes and drug targeting.

Module – IV

Biopharmaceuticals: Understanding principles of pharmacology, pharmacodynamics; Study of a few classes of therapeutics like Recombinant therapeutics, Monoclonal Antibodies, Vaccines, Gene therapy, Antibiotics and Hormones.

References:

1. Lachman, L. et al., *The Theory and Practice of Industrial Pharmacy,* 3rd Edition, Varghese Publishing House, 1987.
2. Aulton, M.E. *Pharmaceutics: The Science of Dosage form Design,* 2nd Edition, Churchill Livingstons, 2002.
3. Ansel, H.C. etal., *Pharmaceutical Dosage Forms and Drug Delivery Systems*, 7th Edition, Lippincott Williams, Wilkins, 2002.
4. Nogardy Thomas, *Medicinal Chemistry: A Molecular and Biochemical Approach,* 3rd Edition, OUP, 2005.
5. Rawlins, E.A, *Bentley's Textbook of Pharmaceutics,* 8th Edition, Baillire, Tindall, 2005.
6. Remington, *The Science and Practice of Pharmacy,* Vol. I and II, 20th Edition, 2007.
7. Banker, G.S. and C.T. Rhodes, *Modern Pharmaceutics,* 4th Edition, Marcel Dekker, 2002.
8. Tripathi, K.D, *Essentials of Medical Pharmacology,* 6th Edition, Jaypee Bros. Med. Publishers, 2008.
9. Andrew Leach, *Molecular Modeling: Principles and Applications, 2nd Edn, Pearson Education, Singapore*
10. Hans Pieter, Heltje and Gerd Folkens, *Molecular Modelling,* VCH.
11. Jonathan M. Goodman, *Chemical Applications of Molecular Modelling,* Springer Verlag.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours Maximum Total Marks: 100

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course outcome:

This course shall provide the necessary theoretical background needed to design and develop novel drugs for existing as well as emerging ailments. The knowledge acquired herein could be applied gainfully in the course of a future career in biopharmaceutical research.

13.706 REACTION ENGINEERING AND PROCESS CONTROL LAB (B)

Teaching Scheme: 0(L) - 0(T) - 3(P) **Credits**: 3

Course Objectives:

This course is aimed at imparting practical hands-on training on the operation of key equipments in reaction engineering and process control. Results of experiments done using laboratory prototypes should be adequately correlated with industrial situations, through appropriate instructional methodology.

LIST OF EXPERIMENTS

GROUP A

1. Kinetic studies and determination of activation energy in an isothermal batch reactor
2. Kinetics studies and determination of activation energy in a isothermal plug flow reactor
3. Kinetics studies and determination of activation energy in an isothermal CSTR
4. Kinetics studies and determination of activation energy in an isothermal semi-batch reactor.
5. Kinetics in an isothermal PFR followed by an isothermal CSTR
6. RTD studies in a PFR
7. RTD studies in a CSTR
8. RTD studies in a packed bed reactor
9. RTD studies in a fluidized bed reactor
10. RTD in CSTR's in series
11. Measurement of surface area and porosity of solid catalysts.

GROUP B

12. Study of dynamic response of first order systems and determination of time constant in measuring instruments
13. Study of dynamic response of second order systems and determination of time constant in measuring instruments.
14. Study of dynamic response in single tank level control system
15. Study of dynamic response in two tanks non-interacting level control system
16. Study of dynamic response in two tanks interacting level control system

GROUP C

17. Study of valve characteristics
18. Optimum controller settings for laboratory scale temperature control system
19. Optimum controller settings for laboratory scale pressure control system
20. Optimum controller settings for laboratory scale level control system
21. Tuning of controllers for distillation control system.

22. Selected laboratory experiments based on calibration of pressure gauges, pneumatic differential pressure transmitters, dynamics of filled thermometer, pressure tank and proportional controller, feed back control of liquid level and temperature systems, computer control of temperature and pressure.

Note: Minimum 12 experiments shall be offered. The minimum number of experiments to be done from groups A, B and C are respectively 6, 4 and 2.

Internal Continuous Assessment *(Maximum Marks-50)*

40% - Test

40% - Class work and Record

20% - Regularity in the class

University Examination Pattern:

Examination duration: 4 hours *Maximum Total Marks: 100*

80% - Procedure, conducting experiment, results, tabulation and inference
20% - Viva voce

Candidate shall submit the certified fair record for endorsement by the external examiner.

Course Outcome:

This course shall enable the students to acquire practical skills on the operation of industrial equipments for reaction and process control applications. They should be able to clearly demarcate laboratory experimentation from industrial practice, with the aid of a unique mode of instruction used in delivering this course.

13.707 DOWNSTREAM PROCESSING LAB (B)

Teaching Scheme: 0(L) - 0(T) - 3(P) **Credits**: 3

Course Objectives:

This course is aimed at offering practical training on the operation of bioseparations equipment, which the students have learned about, in the theory course on Downstream processing. Emphasis is primarily on operation of equipments, and application of techniques for bioseparations at the lab scale. Industrial scale separations could be explained through tutorials and industrial visits, if necessary.

LIST OF EXPERIMENTS

I. Cell disruption:

- *Ultrasonication*
- *Enzymatic cell Lysis*
- *Cell lysis using organic solvents*
- *Mechanical cell disruption* (Bead mills / Dyno mills)

II. Solid- liquid separations (Removal of insolubles):

Flocculation

- Determination of optimum dosage of a flocculant required for recovery of microbial cells from aqueous systems.
- Comparison of flocculating power of different flocculants.

Vacuum filtration/pressure filtration

- Batch pretreatment test- effect of flocculant dosage on filtration rates.
- Determination of various parameters for batch filtration of microbial cell suspensions/ fermentation broths.

III. Product isolation and enrichment:

Membrane separation processes

- Batch and continuous membrane filtration for isolation of proteins (Ultrafiltration) and microbial cells (Microfiltration)
- Demonstration of diafiltration, complete recycle, batch concentration and purification modes of operation of membrane filtration equipment.

Precipitation

- Isoelectric precipitation- Determination of Isoelectric point of proteins and isolation of proteins from aqueous systems by pH change.
- Salting out: Determination of Cohn's constants, validation of Lyotropic series.

- Organic solvent mediated precipitation: Concentration of proteins from aqueous systems by addition of organic solvents

Extraction

- Aqueous two phase extraction of proteins/enzymes from aqueous systems.
- Solvent extraction for concentration of antibiotics / organic acids from fermentation broths.

Batch adsorption as a method of bioproduct isolation.

IV. **Product purification:**

Chromatography

- Ion exchange chromatography
- Gel filtration (Molecular sieving)
- Electrophoresis

V. **Product polishing:**

Crystallization

Vacuum drying

Internal Continuous Assessment *(Maximum Marks-50)*

40% - Test
40% - Class work and Record
20% - Regularity in the class

University Examination Pattern:

Examination duration: 4 hours *Maximum Total Marks: 100*

80% - Procedure, conducting experiment, results, tabulation and inference
20% - Viva voce

Candidate shall submit the certified fair record for endorsement by the external examiner.

Course Outcome:

This course shall provide a clear picture of small scale separations in the biotechnology. Students should be able to apply their knowledge of bioseparations to diverse industrial situations, with a modest degree of supplementary industrial training, which they could acquire after completion of their under graduation.

13.708 MINI- PROJECT (B)

Teaching Scheme: 0(L) - 0(T) - 3(P) **Credits**: 3

Course Objectives:

The mini-project is to be considered as a prequel to the main project work, the students shall have during the higher semester. All necessary background information required to pursue an effective final project should be collated at this level itself. An acceptable minimum level of practical work should be compulsorily done and the feasibility of the proposed work should be proven with supporting theoretical and practical evidence at the end of the mini project.

Every student will be required to submit a project report in a typed form. The topic is to be selected by the student, but specifically approved by the faculty member who guides the student. The mini project work on the topic will consist of either some investigational work on an experimental set up or prototype equipment of some development work, computer simulation or design problem. Every student will be orally examined in the topic selected by the student on completion of the work.

The student will be required to submit three copies of his/her project report to the department office for record before the last working day of the semester (One copy each for the department library, participating faculty and students own copy). So the work on the mini project shall be commenced in the very starting of the semester.

Internal Continuous Assessment *(Maximum Marks-50)*

40% - Assessment by Guide (20% weightage for Report)
40% - Assessment by Evaluation Committee (three member committee out of which one member is the guide)
20% - Regularity in the class

University Examination Pattern:

Maximum Total Marks: 100

80% - Based on quality of work, report and presentation of the mini project
20% - Viva voce

Candidate shall submit the certified report for endorsement by the external examiner.

Course Outcome:

At the end of this course, the students should have selected the appropriate area on which they shall pursue their project work during the higher semester. They should have collected relevant background information and should have produced convincing and conclusive evidence (both theoretical and practical) in support of the feasibility of their proposed project.

13.708 SEMINAR, INDUSTRIAL VISITS (B)

Teaching Scheme: 0(L) - 0(T) - 3(P) **Credits**: 3

Course Objectives:

The seminar is aimed at exposing the undergraduate student to public presentations. This is extremely pivotal to ensure a successful professional career in future. Industrial visits are aimed at exposing students to real life industrial situations and to instill a motivation for pursuing a covetable job as a process engineer in future.

SEMINAR

Each student has to present a seminar for the duration specified by the department before the audience consisting of students and members of the faculty of the department on a topic which is selected by the student in consultation with the internal project guide. The student will be required to submit three copies of his/her seminar report to the department office for record (One copy each for the department library, participating faculty and students own copy).

INDUSTRIAL VISITS

Each student has to submit three copies of a report of the visits to various industries, research institutes etc., which they have visited as part of the B. Tech course (as per the requirements of the curriculum and regulations of the University for the 2013 scheme). A minimum of five industries should be visited and proof of visits duly attached to the reports. The reports of industrial visits could be summoned for verification by the university, if found necessary.

Internal Continuous Assessment *(Maximum Marks-100)*

- ***Seminar*** *(50 marks)*
  - *Attendance: 5 marks*
  - *Guide' s share: 10 marks*
  - *Evaluation committee: 25 marks*
  - *Report: 10 marks*
- ***Industrial Visits*** *(50 marks)*
  - *Attendance: 10 marks*
  - *Report : 10 marks*
  - *Evaluation committee: 30 marks*

Candidate shall submit the certified report for verification by the external examiner during Viva-Voce in VIII Semester.

Course Outcome:

This course shall provide students adequate exposure to public presentations (through seminars) and real-life industrial situations (through industrial visits), which could aid them in building a successful career as a process engineer.