# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
## Scheme of Teaching and Examination – 2018-19
## M.Tech BIOCHEMICAL ENGINEERING (BCE)
## Choice Based Credit System (CBCS)

**I SEMESTER**

| Sl. No | Course | Course Code | CourseTitle | Teaching Hours /Week | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | Practical/Fieldwork/ Assignment | Duration in hours | CIE Marks | SEE Marks | Total Marks | |
| 1 | PCC | 18BCE11 | NUMERICAL METHODS | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 2 | PCC | 18BCE12 | PROCESS AUTOMATION | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 3 | PCC | 18BCE13 | BIO PROCESS ENGINEERING | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 4 | PCC | 18BCE14 | BIOREACTORS | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 5 | PEC | 18BCE15X | PROFESSIONAL ELECTIVE -1 | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 6 | PCC | 18BCEL16 | PROCESS AUTOMATION LAB | - | 04 | 03 | 40 | 60 | 100 | 2 |
| 7 | PCC | 18RMI17 | RESEARCH METHODOLOGY AND IPR | 02 | -- | 03 | 40 | 60 | 100 | 2 |
| | | | **TOTAL** | **22** | **04** | **21** | **280** | **420** | **700** | **24** |

**Note: PCC: Professional core, PEC: Professional Elective.**

### Professional Elective 1

| Course Code under 18BCE15X | Course title |
|---|---|
| 18BCE151 | TRANSPORT PHENOMENA IN BIOPROCESS SYSTEM |
| 18BCE152 | MATHEMATICAL MODELING IN BIOCHEMICAL ENGINEERING |
| 18BCE153 | FOOD TECHNOLOGY |
| 18BCE154 | ENZYME TECHNOLOGY |

**Internship:** All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination will be conducted during III semester and prescribed credit shall be included in the III semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during subsequent University examination after satisfy the internship requirements.

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI**
**Scheme of Teaching and Examination – 2018-19**
**M.Tech BIOCHEMICAL ENGINEERING (BCE)**
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**II SEMESTER**

| Sl. No | Course | Course Code | Course Title | Teaching Hours /Week | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | Practical/Field work/Assignments | Duration inhours | CIE Marks | SEE Marks | Total Marks | |
| 1 | PCC | 18BCE21 | BIO-SEPARATION & DOWNSTREAM PROCESSING | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 2 | PCC | 18BCE22 | BIOREACTOR PLANT DESIGN | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| | | | CHEMICAL AND BIOCHEMICAL | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 3 | PCC | 18BCE23 | REACTIONS | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 4 | PEC | 18BCE24X | PROFESSIONAL ELECTIVE 2 | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 5 | PEC | 18BCE25X | PROFESSIONAL ELECTIVE 3 DOWNSTREAM | -- | 04 | 03 | 40 | 60 | 100 | 2 |
| 6 | PCC | 18BCEL26 | PROCESSING LAB | -- | 02 | -- | 100 | -- | 100 | 2 |
| 7 | PCC | 18BCE27 | TECHNICAL SEMINAR | **22** | **06** | **20** | **380** | **420** | **800** | **24** |
| | | | **TOTAL** | | | | | | | |

**Note: PCC: Professional core, PEC: Professional Elective,**

| **Professional Elective 2** | | **Professional Elective 3** | |
|---|---|---|---|
| **Course Code under 18BCE23X** | **Course title** | **Course Code under 18BCE24X** | **Course title** |
| 18BCE241 | SAFETY MANAGEMENT IN BIOPROCESS INDUSTRIES | 18BCE251 | TOTAL QUALITY MANAGEMENT |
| 18BCE242 | BIOSENSORS | 18BCE252 | BIOPROCESS OPTIMIZATION, MODELING & SIMULATIONS |
| 18BCE243 | BIOPROCESS CONTROL & INSTRUMENTATION | 18BCE253 | NANOBIOTECHNOLOGY AND ITS APPLICATION IN BIOPROCESS INDUSTRIES |

**Note:**

**1. Technical Seminar:** CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide in any and a senior faculty of the department. Participation in seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.

The CIE marks awarded for Technical Seminar shall be based on the evaluation of Seminar Report, Presentation skill and Question and Answer session in the ratio 50:25:25.

**2. Internship:** All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination will be conducted during III semester and prescribed credit shall be included in the III semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during subsequent University examination after satisfy the internship requirements.

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
## Scheme of Teaching and Examination – 2018-19
## M.Tech BIOCHEMICAL ENGINEERING (BCE)
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**III SEMESTER**

| Sl. No | Course | Course Code | Course Title | Teaching Hours /Week | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | Practical/Field work/Assignment | Duration inhours | CIE Marks | SEE Marks | Total Marks | |
| 1 | PCC | 18BCE31 | BIOENERGY | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 2 | PCC | 18BCE32 | QC, QA & VALIDATION | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 3 | PEC | 18BCE33X | PROFESSIONAL ELECTIVE - 4 | 04 | -- | 03 | 40 | 60 | 100 | 4 |
| 4 | Proj | 18BCE34 | EVALUATION OF PROJECT PHASE -1 | -- | 02 | -- | 100 | -- | 100 | 2 |
| 5 | INT | 18BCEI35 | INTERNSHIP | (Completed during the intervening vacation of I and II semesters and /or II and III semesters.) | | 03 | 40 | 60 | 100 | 6 |
| **TOTAL** | | | | 12 | 02 | 12 | **260** | **240** | **500** | **20** |

**Note: PCC: Professional core, PEC: Professional Elective, OEC: Open Elective, Proj: Project, INT: Internship**

**Professional elective 4**

| Course Code under 18BCE32X | Course title |
|---|---|
| 18BCE331 | BIOLOGICAL WASTE TREATMENT |
| 18BCE332 | BIOLOGICAL THERMODYNAMICS |
| 18BCE333 | FERMENTATION TECHNOLOGY |
| 18BCE334 | ANIMAL CELL CULTURE AND TISSUE ENGINEERING |

**Note:**

**1. Project Phase-1:** Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide and a senior faculty of the department.The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE (University examination) shall be as per the University norms.

**2. Internship:** Those, who have not pursued /completed the internship, shall be declared as failed and have to complete during subsequent University examinations after satisfy the internship requirements.

Internship SEE (University examination) shall be as per the University norms.

**VISVESVARAY A TECHNOLOGICAL UNIVERSITY, BELAGAVI**
**Schem e of Teaching and Examination – 2018- 19**
**M.T ech BIOCHEMICAL ENGINEERING (BCE)**
**Choice Based Credit System (CBCS)**

**IV SEMESTER**

| Sl. No | Course | Course Code | Course Title | Teaching Hours /Week | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | Practical/Fieldwork/Assignment | Duration inhours | CIE Marks | SEE MarksViva voce | Total Marks | |
| 1 | Project Work | 18BCE41 | PROJECT WORK PHASE -2 | -- | 04 | 03 | 40 | 60 | 100 | 20 |
| | | | **TOTAL** | **--** | **04** | **03** | **40** | **60** | **100** | **20** |

**Note: Proj: Project.**

**Note:**

**1. Project Phase-2:**

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any and a Senior faculty of the department. The CIE marks awarded for project work phase -2 shall be based on the evaluation of Pro ject Report subjected to plagiarism check, Project Presentation skill and Questi on and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Proj ect work evaluation and Viva-Voce examination (SEE), aft er satisfying the plagiarism check, shall be as per the University norms.

**NUMERICAL METHODS**
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE11 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

**Course objectives:**
The Students will
1. Equip with statistical tools and concepts that help in decision making.
2. Understand the probability and able to design an experiments

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **INTRODUCTION**<br>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). | **10** | **L1,L2** |
| **MODULE –2** | | |
| **BI-VARIATE DISTRIBUTION**<br>Correlation and regression analysis (simple and linear) curve fitting (linear, non-linear and exponential).<br>**PROBABILITY**<br>Axioms, models, conditional probability, Bayes rule, Genetic Applications of Probability, Hardy - Weinberg law, Wahlund's Principle, Forensic probability determination, Likelihood of paternity, Estimation of probabilities for multi-locus/multi-allele finger print systems. | **10** | **L1,L2** |
| **MODULE – 3** | | |
| Discrete probability distributions - Binomial, Poisson, geometric – derivations. Central limit theorem.<br>Continuous probability distribution – normal, exponential, gamma distributions, beta and Weibull distributions, T & F distributions. | **10** | **L3,L4** |

| | | |
|---|---|---|
| **MODULE – 4** | | |
| **STATISTICAL INFERENCE**<br>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). | **10** | **L2, L3** |
| **MODULE – 5** | | |
| **DESIGN OF EXPERIMENTS**<br>Sample surveys, comparisons groups and randomization, random assignments, single and double blind experiments, blocking and extraneous variables, limitations of experiments.<br>**CASE STUDIES:**<br>Statistical tools for setting in process acceptance criteria; T-Test based approach for confirming human antibody response to therapeutic drug; Population statistics for cases related to cigarette smoking, Lung cancer, endangered plants species, epidemics etc. | **10** | **L1, L2, L3** |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT 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

**REFERENCE BOOKS**

- Wolfgang Boehm and Hartmut Prautzsch, Numerical Methods, CRC Press, 1993..
- John F. Monahan. Numerical Methods of Statistics (Cambridge Series in Statistical and Probabilistic Mathematics), Cambridge University Press, 2011.
- Joe D. Hoffman. Numerical Methods for Engineers and Scientists, CRC Press, 2nd Edition, 2001.
- Warren J. Ewens Gregory Grant, Statistical Methods in Bioinformatics: An Introduction

# PROCESS AUTOMATION

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

SEMESTER – I

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE12 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

**Course objectives:**

The Students will

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| REVIEW OF SYSTEMS:<br>Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Control valve types- linear, equal percentage and quick opening valves. Transient response. Block diagrams. | **10** | **L1,L2** |
| **MODULE –2** | | |
| STABILITY ANALYSIS:<br>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. | **10** | **L1,L2,L3** |
| **MODULE – 3** | | |
| SPECIAL CONTROL TECHNIQUES:<br>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. | **10** | **L3, L4** |
| **MODULE – 4** | | |
| MULTIVARIABLE CONTROL:<br>Analysis of multivariable systems, Interaction, examples of storage tanks. Review of matrix algebra, Bristol arrays, Niederlinski index – Tuning of multivariabl e controllers. | **10** | **L2, L3, L4** |
| **MODULE – 5** | | |

| | | |
|---|---|---|
| SAMPLE DATA CONTROLLERS:<br>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. | **10** | **L1, L2, L3** |

**Course outcomes:**

After studying this course, students will be able to:

1. Evaluate the response of first and higher order system and analyze the stability of control system
2. Identification of proper advanced control techniques for different process and design of controller for multivariable process control system
3. Understanding the sampled data system and identify the response of discrete system.

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT BOOKS:**

1. Coughnour D R, " **Process system analysis and control**"- 2 nd 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

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE13 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **INTRODUCTION:** Bioprocess development an interdisciplinary challenge, introduction to engineering calculations, presentation of analysis of data, regulatory constraints for bioprocess engineering. Bioprocess engineering and technology. Role of a Chemical engineer in a bioprocess industry. Classification of micro-organisms, Taxonomy, Environmental and Industrial microbiology. | **10** | L1, L 2 |
| **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. | **10** | L1, L 2 |
| **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 | **10** | L3, L4 |
| **MODULE – 4** | | |
| **MIXED CULTURES:** Introduction to mixed cultures, Major Classes of Interactions: Simple Models, Competition between two species, Prey-Predator system, Lotka-Volterra Model Web Interaction, Population dynamics in models of mass action form. | **10** | L2, L3 |
| **MODULE – 5** | | |
| **INDUSTRIAL BIOPROCESS:** Anaerobic process: Ethanol, lactic acid, acetone-butanol production. Aerobic Processes: Citric Acid, Baker's Yeast, Penicillin, High fructose corn syrup production. | **10** | L1, L2. L3 |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT 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

# BIOREACTORS

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE14 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **INTRODUCTION TO BIOREACTORS:** Overview of biological reactors: submerged liquid fermentation, solid state fermentation, Understanding of bioreactors: Definition of bioreactor, development of bioreactors, Purpose and importance of bioreactor, Classification of bioreactors, bioreactor for animal cell, plant cell cultivation/culture. | **10** | L1, L 2 |
| **MODULE – 2** | | |
| **TRANSPORT PHENOMENA IN BIOPROCESS SYSTEMS:** Gas liquid mass transfer in Cellular Systems. Determination of $O_2$ transfers 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. | **10** | L2, L3 |
| **MODULE – 3** | | |
| **BIOREACTOR OPERATIONS:** Common operations of bioreactor, selection and identifications of factors for smooth operations of bioreactors, spectrum of basic bioreactor operations, bioreactor operations for immobilizes systems, plant and animal cell bioreactors operation | **10** | L3 |

| | | |
|---|---|---|
| **MODULE – 4** | | |
| **CONTROLS IN BIOREACTORS**<br>Control task in bioreactor system, instrumentation in bioreactors, control variables and measurement devices, advanced control technique, consistency checks on measurement, adaptive online optimizations. Online and off line measurements and analytical methods. | **10** | L2, L3 |
| **MODULE – 5** | | |
| **STERLISATION AND SCALE UP OF BIOREACTORS:**<br>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. | **10** | L3 |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT BOOK:**

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

**REFERENCE BOOK**

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

# TRANSPORT PHENOMENA IN BIOPROCESS SYSTEM

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

SEMESTER – I

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE151 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

**Course objectives:**

The Students will

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| Gas-Liquid Mass Transfer in Cellular System, Basic Mass- Transfer Concepts, Rates of Metabolic Oxygen Utilization, Determination of Oxygen Transfer Rates, Measurement of kıa' 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 | **10** | **L1, L2** |
| **MODULE –2** | | |
| Forced Convection Mass Transfer, General Concepts Dimensionless Groups, Correlations for Mass-Transfer Coefficients and Interfacial Area, Mass Transfer Across Free Surfaces Factors Effecting kıa', 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 | **10** | **L1, L2** |
| **MODULE – 3** | | |
| TEMPERATURE DISTRIBUTION IN SOLIDS AND IN LAMINAR FLOW: Different situations of heat transfer: Heat conduction with internal generation by electrical, nuclear, viscous energy sources. Numerical problems using the equations derived in the above heat transfer situations. Heat conduction in a cooling fin: Forced and free convection heat transfer HEAT | **10** | **L3,L4, L5** |

| | | |
|---|---|---|
| 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. | **10** | **L2, L3** |
| **MODULE – 5** | | |
| ANALOGIES BETWEEN MOMENTUM, HEAT AND MASS TRANSPORT: Numerical problems using Reynold's, Prandtl's and Chilton & Colburn analogie s. 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 | **10** | **L1, L2, L3** |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT 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

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE152 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

**Course objectives:**
The Students will
1. Understand physical systems in Chemical and Biochemical engineering.
2. Develop mathematical models for Chemical and Biochemical systems.
3. Solve and analyze process models using different mathematical techniques.

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **Numerical Techniques:** Simultaneous linear algebraic equation– Gauss Jordan, Non-linear algebraic equation–Newton Raphson, Ordinary Differential Equation–R-K Method, Numerical Integration – Simpson's 1/3 Rule . Applications: Vapor –Liquid equilibria for binary mixtures, Calculation of Bubble Point Dew point for ideal binary mixture | **10** | L1, L 2, L3, |
| **MODULE – 2** | | |
| **Bioreactor:** Operational stages in a Bioprocess industry, biochemical reactor, continuous stirred tank bioreactor- process description, mathematical model, fed-batch bioreactor- model development | **10** | L2, L3 |
| **MODULE – 3** | | |
| **Design:** Double Pipe Heat Exchanger (Area, Length and Pressure drop), Shell & Tube Heat Exchanger (Area, Number of tubes, Pressure drop) | **10** | L 2, L3, L4 |
| **MODULE – 4** | | |
| **Modeling:** Applications of law of conservation of mass in mixing tank system, equilibrium still and single stage extraction. Heat transfer through multiwall cylinders and spheres, heat transfer in a jacketed vessel, rate expression for series and parallel homogenous first order reactions | **10** | L2, L3 |
| **MODULE – 5** | | |

| | | |
|---|---|---|
| **Mathematical Modeling and Solutions to the Following:** Basic tank model – Level V/s time, batch Distillation–Vapour composition with CSTRs in serie s | **10** | L2, L3. |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT BOOKS:**

1. 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

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE153 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **Introduction and Quality Attributes of Food:** Function of foods. Food in relation to health. Aim of food science and technology. Quality attributes – Appearance fac tors, Textural factors, Flavour factors. Visual and objectively measurable attributes. Aroma of foods – introductor y 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. | **10** | L1, L2 |
| **MODULE – 2** | | |
| **Food Processing and Preservation:** Food deterioration – Causes. Aims and objectives of preservation and processing. Unit operations in processing. Different methods of food preservation – low temperature, hig h 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. | **10** | L1, L2 |

| | | |
|---|---|---|
| **MODULE – 3** | | |
| **Enzymatic and Non-Enzymztic reactions during storages:**<br>Introduction to enzymes. Nature and function of enzymes. Classification of enzymes. Hydrolases – Esteraus, amylases, pectic enzymes. Proteases. Oxidoreductases – phenolases, glucose oxidase, cata lose, peroxidase, lipoxygenase, xantine oxidase. Immobilized enzymes. Uses and suggested uses of enzyme in food processing. Non-enzymatic reactions. | **10** | L3, L4 |
| **MODULE – 4** | | |
| **Food Additives:** Introduction and need for food additives. Types of additives – antioxidants, chela ting 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. Sta bilizers and thickeners, other additives. Additives and food safety. | **10** | L2, L3 |
| **MODULE – 5** | | |
| **Food Contamination and Adulteration: Types** of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards.<br>**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. | **10** | L1, L2. L3 |
| **Course outcomes:**<br>After studying this course, students will be able to:<br>1. Comprehend the physical properties of food and its transportation.<br>2. Identify sources of contaminants, adulterants with the prevention for safe and healthy food.<br>3. Discern different technologies involved in food processing.<br>4. Select biocompatible packaging and additives for food products | | |
| **Graduate Attributes**<br>1. Scholarship & Knowledge<br>2. Critical Thinking<br>3. Research skill<br>4. Life long learning | | |
| **Question paper pattern:**<br>• The question paper will have ten questions.<br>• Each full question consists of 16 marks.<br>• There will be 2full questions (with a maximum of four sub questions) from each module.<br>• Each full question will have sub questions covering all the topics under a module.<br>• The students will have to answer 5 full questions, selecting one full question from each module. | | |

**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.

# ENZYME TECHNOLOGY

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE154 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| STRUCTURES AND FUNCTIONS OF PROTEINS: Enzyme classification, based on structure classification of amino acids, classifications of proteins, specificities of enzyme action, biosynthesis and properties of proteins. | **10** | L1, L 2 |
| **MODULE – 2** | | |
| KINETICS: Chemical mechanisms of enzyme catalysed reactions, introduction to bioenergetics and kinetics, kinetics of multi-substrate bioreactions, investigations of active sites structures. | **10** | L2, L3, L4 |
| **MODULE – 3** | | |
| CHEMICAL NATURE OF ENZYME CATALYSIS: Sigmoidal kinetics and allosteric enzymes, co-enzymes, significance of sigmoidal behaviour. | **10** | L 2, L3, |
| **MODULE – 4** | | |
| APPLICATIONS: Investigation of enzymes in biological preparation, extraction and purification, enzymes as analytical reagents | **10** | L3, L4 |
| **MODULE – 5** | | |

| | | |
|---|---|---|
| INSTRUMENTAL TECHNIQUES:<br>Instrumental techniques available for using enzymatic analysis, applications in medicine, industries, and biotechnological applications | **10** | L2, L3, L4 |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT BOOKS:**

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

**REFERENCE BOOKS:**

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

# PROCESS AUTOMATION LABORATORY

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCEL16 | CIE Marks : | 40 |
| Hours/week : | 01 Hr Tutorial (Instructions) + 03 Hours Laboratory | Exam Hrs. : | 3 |
| Total Hours : | 48 | SEE Marks : | 60 |

**CREDITS – 02**

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

| SL NO | LABOATORY EXPERIMENTS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **1.** | Time constant of a Thermometer response | **L3, L4** |
| **2.** | Second Order system U Tube Monometer | **L3, L4** |
| **3.** | Single Tank – Step response | **L3, L4** |
| **4.** | Interacting tanks- Step Response | **L3, L4** |
| **5.** | Interacting tanks Pulse Response | **L3, L4** |
| **6.** | Non-Interacting tanks- Step Response | **L3, L4** |
| **7.** | Non-Interacting tanks- Pulse Response | **L3, L4** |
| **8.** | P, PI and PID controller trainer | **L3, L4 L5** |
| **9.** | Valve characteristics | **L3, L4** |

**Course outcomes:**
After studying this course, students will be able to:
1. Apply theoretical knowledge of response of first order response by hand on with thermometer system and single tank flow system.
2. Acquire practical knowledge of second order system response with tank in series system and U tube manometer.
3. Control level and temperature using P, PI and PID controller and examine valve characteristics.

**Graduate Attributes**
1. Critical Thinking
2. Usages of Modern Tools

| |
|---|
| 3. Collaborative and Multidisciplinary Work<br>4. Life Long Learning<br>5. Independent and Reflective Learning |
| **Conduct of Practical Examination:**<br>1. All laboratory experiments are to be included for practical examination.<br>2. Students are allowed to pick one experiment from the lot.<br>3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.<br>4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero. |
| **REFERENCES:**<br>1. George Stephanopoules, " **Chemical process control, An Introduction to Theory and Practical**" - Prentice Hall, New Delhi, 1998.<br>2. Smith C A and Corripio A B " **Principles and practice of automotive process control**"-John Wiley, New York, 1976.<br>3. Luyben " **Process Modelling, Simulation and Control for chemical Engineers**"- 2nd edn,, McGraw Hill, 1990. |

RESEARCH METHODOLOGY AND IPR
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

| | | | |
|---|---|---|---|
| Sub. Code : | 18RM17 | CIE Marks : | 40 |
| Hours/week : | 2 | Exam Hrs. : | 3 |
| Total Hours : | 25 | SEE Marks : | 60 |

**CREDITS – 02**

**Course objectives:** This course will enable students to learn

- To give an overview of the research methodology and explain the technique of defining a research problem
- To explain the functions of the literature review in research.
- To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review.
- To explain various research designs and their characteristics.
- To explain the details of sampling designs, measurement and scaling techniques and also different methods of data collections.
- To explain several parametric tests of hypotheses and Chi-square test.
- To explain the art of interpretation and the art of writing research reports.
- To explain various forms of the intellectual property, its relevance and business impact in the changing global business environment.
- To discuss leading International Instruments concerning Intellectual Property Rights

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **Research Methodology:** Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India. **Defining the Research Problem:** Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration. | **05** | **L1,L2** |
| **MODULE –2** | | |
| **Reviewing the literature:** Place of the literature review in research, Bringing clarity and focus to your research | **05** | |

| | | | |
|---|---|---|---|
| problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed. | | **L1,L2** | |
| **MODULE – 3** | | | |
| **Design of Sampling:** Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs. **Measurement and Scaling:** Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Techniques, Multidimensional Scaling, Deciding the Scale. **Data Collection**: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method | **05** | **L1, L2** | |
| **MODULE – 4** | | | |
| Testing of Hypotheses: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis. Chi-square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests. | **05** | **L1, L2, L3, L4** | |
| **MODULE – 5** | | | |
| **Interpretation and Report Writing:** Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports. **Intellectual Property:** The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act,1999,TheDesigns Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi- | **05** | **L1, L2,L3, L4, L5** | |

| | | |
|---|---|---|
| Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO | | |

**Course outcomes:**

After studying this course, students will be able to:

- Discuss research methodology and the technique of defining a research problem
- Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
- Explain various research designs and their characteristics.
- Explain the details of sampling designs, measurement and scaling techniques and also different methods of data collections
- Explain several parametric tests of hypotheses and Chi-square test.
- Explain the art of interpretation and the art of writing research reports.
- Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.

**Graduate Attributes (as per NBA):**

- Problem Analysis
- Societal concern
- Life-long Learning

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.

- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS**

- Research Methodology: Methods and Techniques by C.R. Kothari, Gaurav Garg, New Age International, 4th Edition, 2018.
- Research Methodology a step-by-step guide for beginners. (For the topic Reviewing the literature under module 2) by Ranjit Kumar, SAGE Publications Ltd, 3rd Edition, 2011
- Study Material (For the topic Intellectual Property under module 5)-Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013

**REFERENCE BOOKS**

- An introduction to Research Methodology by Garg B.L et al., RBSA Publishers, 2002
- An Introduction to Multivariate Statistical Analysis by Anderson T.W, Wiley, 3rd Edition, 2003.
- Research Methodology by Sinha, S.C, Dhiman, EssEss Publications, 2002.
- Research Methods: the concise knowledge base by Trochim, Atomic Dog Publishing, 2005.
- How to Write and Publish a Scientific Paper by Day R.A, Cambridge University Press, 1992.
- Conducting Research Literature Reviews: From the Internet to Paper by Fink A, Sage Publications, 2009.
- Proposal Writing by Coley S.M. Scheinberg, C.A, Sage Publications, 1990
- Intellectual Property Rights in the Global Economy by Keith Eugene Maskus, Institute for International Economics, 2000

| BIOSEPARATION AND DOWNSTREAM PROCESSING<br>[As per Choice Based Credit System (CBCS) scheme]<br>SEMESTER – II | | | |
|---|---|---|---|
| Sub. Code : | 18BCE21 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |
| **CREDITS – 04** | | | |

**Course objectives:**
The students will
1. Understand downstream processing techniques for processing of biomolecules with emphasis on purification of bio-products
2. Comprehend the membrane separations and freeze drying techniques

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **INTRODUCTION**<br>Role and importance of downstream processing in biotechnological processes. Problems and requirements of byproduct purification. Economics of downstream processing in Biotechnology. Cost cutting strategies,<br>Characteristics of biological mixtures, Process design criteria for various classes of byproducts (high volume, low value products and low volume, high value products), Physico-chemical basis of different bio-separation processes. | **10** | **L1, L2** |
| **MODULE – 2** | | |
| **PRIMARY SEPARATION TECHNIQUES**<br>Cell disruption methods for intracellular products, removal of insolubles, biomass (and particulate debris) separation techniques; flocculation and sedimentation,<br>Centrifugation (ultra and differential) and filtration methods. Solid-liquid separation with theory of batch filtration, Theories of Centrifugal force, equipments and centrifugal filtrations, numericals. | **10** | L1, L 2, L3, L4 |
| **MODULE – 3** | | |
| **ISOLATION AND PRODUCT PURIFICATION:**<br>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 | **10** | L3, L4 |

| | | |
|---|---|---|
| focusing | | |
| **MODULE – 4** | | |
| **MEMBRANE SEPARATION PROCESSES**<br>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. | **10** | L2, L3 |
| **MODULE – 5** | | |
| **FINISHING OPERATIONS AND FORMULATIONS**<br>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 | **10** | **L1, L2, L3** |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT BOOK**

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

**REFERENCE BOOKS**

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

| BIOREACTOR DESIGN<br>[As per Choice Based Credit System (CBCS) scheme]<br>SEMESTER – II | | | |
|---|---|---|---|
| Sub. Code : | 18BCE22 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |
| **CREDITS – 04** | | | |

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **INTRODUCTION TO DESIGN:** Basic considerations in design. General design procedure. Equipment classification. Various components of process equipment.<br>Design parameters. Pressure vessel codes. Material selection. Factors affecting design. | **10** | L1, L2 |
| **MODULE – 2** | | |
| MECHANICAL ASPECTS OF BIOREACTOR DESIGN:<br>Introduction, requirement for construction of bioreactor,<br>guidelines for bioreactor design, bioreactor vessels, geometry of vessel, Design of flange, design procedures.<br>**Numerical problems** | **10** | L2, L3 |
| **MODULE – 3** | | |
| DESIGN OF AGITAOR AND POWER RATING:<br>Design of vessel sizing with agitation or mixing, types of<br>agitators, baffles, Design of agitator shaft, power requirement calculations, Numerical problems | **10** | L3 |
| **MODULE – 4** | | |
| **DESIGN OF VESSEL CLOSURES:**<br>Various Vessel closures such as Flat plates or covers<br>formed, torispherical, elliptical, hemispherical and cylindrical designs. Numerical problems | **10** | L2, L3, |

| | | |
|---|---|---|
| **BIOLOGICAL REACTOR:** Detailed process design of biological reactor: Activated sludge process, rotating biological contactor, trickling bed filters, up flow **10** L3 an digester, Numerical problems. | aerobic sludge bl | anket |

**Course outcomes:**

On completion of this course the students will be able to

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT 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

# CHEMICAL AND BIOCHEMICAL REACTIONS

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE23 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **KINETICS OF HETEROGENEOUS REACTIONS**: Catalytic Reactions, Rate controlling steps, Langmuir - Hinshelwood model, Rideal - Eiley Mechanism, Steady State approximation, Non catalytic fluid - solid reactions, Shrinking and unreacted core model. | **10** | L1, L2 |
| **MODULE – 2** | | |
| **POPULATION BALANCE MODELS**: Mixing concepts, Residence Time Distribution, Response measurements, Segregated flow model, Dispersion model, Series of stirred tanks model, Recycle reactor model, Analysis of non-ideal reactors. | **10** | L2, L3, |
| **MODULE – 3** | | |
| **EXTERNAL DIFFUSION EFFECTS IN HETEROGENEOUS REACTIONS:** Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, Modelling diffusion with and without reaction. | **10** | L 2, L3 |
| **MODULE – 4** | | |
| **INTERNAL TRANSPORT PROCESSES IN POROUS CATALYSTS:** Intra pellet mass and heat transfer, Evaluation of effectiveness factor, mass and heat transfer with reaction. | **10** | L3, L4 |
| **MODULE – 5** | | |

| | | |
|---|---|---|
| **DESIGN OF HETEROGENEOUS CATALYTIC REACTORS**:<br>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. | **10** | L3, L4 |

## Course Outcome

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

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

**3.** Apply knowledge of reaction kinetic and flow behavior to design heterogeneous catalytic reactors for different reaction conditions.

**Graduate Attributes**

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

**Question paper pattern:**

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

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

**REFERENCE BOOKS:**

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

## SAFETY MANAGEMENT IN BIOPROCESS INDUSTRIES

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE241 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

**Course objectives:**
Students will
• Acquainted with various aspects of Intellectual rights and their usage to modern Technology
• Understand the hazards and regulation of handling biohazard materials

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **BIOTECHNOLOGY AND SOCIETY**<br>Introduction to science, technology and society, biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries. | **10** | L1, L2, |
| **MODULE – 2** | | |
| **BIO-SAFETY CONCEPTS AND ISSUES**<br>Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards, biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. The Cartagena protocol on biosafety. Biosafety management: Key to the environmentally responsible use of biotechnology. Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons | **10** | L1, L2, |
| **MODULE – 3** | | |
| **BIO-SAFETY IN THE LABORATORY**<br>Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution. | **10** | L1, L2, L5 |
| **MODULE – 4** | | |

| | | |
|---|---|---|
| **REGULATIONS**<br>Good manufacturing practice and Good lab practices (GMP and GLP). GMOs: Concerns and Challenges, Regulatory mechanism for GMO, Case studies in IPR (Turmeric and Neem Patent Case) and Biosafety (Bt Bringal and Bt cotton, Golden Rice) | **10** | L1, L2, L4 |
| **MODULE – 5** | | |
| **FOOD SAFETY**<br>The GM-food debate and biosafety assessment procedures for biotech foods & related products, case studies of relevance. Environmental aspects of biotech applications.<br>**AGRI AND PHARMA SECTOR**<br>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. | **10** | L1, L2, |
| **Course outcomes:**<br>After studying this course, students will be able to:<br>1. Understand the biohazard and its abatement in a safe way.<br>2. Risk analysis, assessment and abatement of hazards for the safe operation of processes in biochemical industries.<br>3. Apprehend process safety in Biotechnological based products in order to comply with industrial & regulatory standards | | |
| **Graduate Attributes**<br>1. Critical Thinking<br>2. Usage of modern tools<br>3. Research Skill<br>4. Ethical Practices and social responsibility<br>5. Independent and reflective thinking | | |
| **Question paper pattern:**<br>• The question paper will have ten questions.<br>• Each full question consists of 16 marks.<br>• There will be 2full questions (with a maximum of four sub questions) from each module.<br>• Each full question will have sub questions covering all the topics under a module.<br>• The students will have to answer 5 full questions, selecting one full question from each module. | | |
| **TEXT BOOK**<br>1. Deepa Goel & Shomini Prasar, IPR, Biosafety, and Bioethics, Pearson Press, New Delhi 2013.<br>2. Thomas JA and Fuch RI (2002) Biotechnology and safety assessment, Academic press 2002. | | |

**REFERENCE**

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

# BIOSENSORS

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE242 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **INTRODUCTION:** A historical perspective; Definition and Expanding Needs of Biosensors; Advantages and limitations; Biosensor Economics; various components of biosensors | **10** | L1, L2 |
| **MODULE – 2** | | |
| **TYPES OF BIOSENSORS:** Biocatalysts based biosensors, bio affinity based biosensors & microorganisms based biosensors, biologically active material and analyte. Types of membranes used in biosensor constructions | **10** | L 2, L 3, |
| **MODULE – 3** | | |
| **TRANSDUCERS IN BIOSENSORS:** Various types of transducers; principles and applications; Bio-, chemi-, and electrochemiluminescence for fiber-optic biosensors; Fluorescencebased fiber-optic biosensors | **10** | L3, |
| **MODULE – 4** | | |
| **KINETIC MODELING FOR BIOSENSORS:** The purpose and practice of modeling; The flux equations, The flux diagram for the membrane/enzyme/electrode, Deriving a complete kinetic model; Kinetic modeling in other types of biosensors- Potentiometric enzyme electrodes, Optical and photometric biosensors, Immunosensors | **10** | L5, |
| **MODULE – 5** | | |

| | | |
|---|---|---|
| **APPLICATION AND USES OF BIOSENSORS:** Biosensors in medicine and health care, biosensors for agriculture and food; Low cost- biosensor for industrial biosensors for environmental monitoring. | **10** L3 | processes for online monitoring; |

**Course outcomes:**

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

1. Explain the basic definition used in the field of sensors.
2. Describe the experimental techniques used for optical sensors, fluorescence-based fibre-optic and biosensors.
3. Model the kinetics of biochemical in order to investigate the specific reaction in the biosensor.
4. Presents and interprets the different applications of biosensors

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT BOOK:**

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

**REFERENCE BOOKS**

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

# BIOPROCESS CONTROL & INSTRUMENTATION

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE243 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

**Course objectives:** This course will enable students to learn

- To, appreciate the concepts underlying in various tools in bioprocess control
- To comprehend the essentials of design of bioprocess control and instrumentation

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **AIMS AND OBJECTIVES OF CONTROL SYSTEMS:** Closed loop control and open loop control systems- Examples, Elements of control system, process variables, process parameters, Representation of control systems in terms of block diagrams and its explanation, Laplace transforms. Z transforms. | **10** | L1, L 2, L3, L4 |
| **MODULE – 2** | | |
| **FUNDAMENTALS OF STATIC AND DYNAMIC CHARACTERISTICS:** Indicators and recorders. Pressure measurement- Bourdon, diaphragm and bellow type gages. Vacuum measurements. Temperature measurement- Bimetal and resistance thermometers, thermocouples and pyrometers, Flow measurement, Level measurement devices, pH and DO analyzers, on-line and off-line analysis of biomass estimation | **10** | L1, L 2, L3, L4 |
| **MODULE – 3** | | |
| **INTRODUCTION TO CONTROLLER**: Mode of action of controllers and the Transfer function, Response of the controller to Step, Pulse, Linear changes to error signals, qualities of good controller, proportional Band. Transmitters, Measurements systems. Measurement of process variables, Actuators, Positioners, Control valves, Valve body, valve Plug, Variable Displacement pumps, and constant output pumps, PLC. Sequential control, Logic and security systems. | **10** | L 2, L3, L4 |
| **MODULE – 4** | | |

| | | |
|---|---|---|
| Block diagram Deduction, Analysis of typical control system-Closed loop analysis -Servo and Regulatory problems for First and second order systems, Closed and loop transfer functions, P-controller for set point change, off-set,P-controller for load change, Pi controller with set point change. Stability. Process identification, Root locus, Routh Array, Bode and Nyquist diagrams. Stability margins. Robustness, Steady state errors. Frequency domain response | **10** | L3, L4. L5 |
| **MODULE – 5** | | |
| Elements of tuning and closed loop dynamics Industrial controllers. Design methodology. Control specifications. PID tuning. Rule and model based tunning. Autotunners. Common control loops. Process design and operability. Control structures. Cascade. Feed forward. Ratio. Examples. Interactive systems. Multivariable processes. RGA. Decoupling control. Design, scale up and optimization of various equipment and biosystems used for biotechnological process industries (equipment used in upstream, downstream and fermentation processes). | **10** | L3, L4. L5 |

**Course outcomes:**

- Demonstrate strong basics in principles of Bioprocess controls and automation techniques
- Design and develop various control systems in bioreactors

**Graduate Attributes (as per NBA):**

- Problem Analysis
- Design / development of solutions.
- Modern Tool Usage

**Question paper pattern:**

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


- Smith & CorrIpio, Principles and practice of automatic process control. John Wiley, 1985.
- LuybenW.L., Luyben M.L., Essentials of process control, Mc Graw-Hill, 1997
- Ogunnake B.A., Ray W.H., Process dynamics, modeling and control, Oxford University Press, 1994


**REFERENCE BOOKS**


- Luyben, Process modeling, simulation and control for chemical engineers. McGraw Hill, 1990.
- McMillan, Tuning and Control loop performance. ISA 1990.
- D E Seborg, T F Edger, Process dynamics and control, John Wiley, 1999

# TOTAL QUALITY MANAGEMENT

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE251 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

**Course objectives:** Students will
1. Understand the main principles of business and social excellence.
2. Use models and quality management methodology for the implementation of total quality management at all scope of business and public sector.
3. Develop an understanding of total quality management principles, frameworks, tools and techniques for effective real life applications in both manufacturing and services.

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **CONCEPTS OF TQM**: Basics of total quality, Guru's of TQM, Philosophy of TQM, customer focus, organization, quality philosophies of Deming, Crossby. | **10** | L1, L2 |
| **MODULE – 2** | | |
| **TQM PROCESS**: QC tools, problem solving methodologies, cost of quality, quality circles, bench marking, strategic quality planning. | **10** | L2, L3 |
| **MODULE – 3** | | |
| **TQM SYSTEMS:** Quality policy deployment, quality function deployment, standardization, designing for quality, manufacturing for quality. | **10** | L3 |
| **MODULE – 4** | | |
| **QUALITY SYSTEM:** Need for ISO 9000 system, advantages, clauses of ISO 9000, Implementation of ISO 9000, quality auditing, case studies. | **10** | L5 |
| **MODULE – 5** | | |
| **IMPLEMENTATION OF TQM**: KAIZEN, 5s, JIT, POKAYOKE, Taguchi methods, case studies. | **10** | L3 |

**Course outcomes:**

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

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT BOOK**

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

**REFERENCE BOOKS**

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

## BIOPROCESS MODELING AND SIMULATION

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE252 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

**Course objectives:**
Students will
1. Learn and develop mathematical models of phenomena involved in various biochemical engineering processes
2. Know the feasible solutions for different models developed

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **INTRODUCTION TO PROCESS MODELING**: Models and model building, model formulation principles. Fundamental laws used in modeling: Continuity Equation, Energy Equation, Equation of motion and transport Equations-equations of state &equilibrium states. Classification of mathematical models: linear & non-linear models, static & dynamic models and lumped & distributed parameter models, with examples for all the models. | **10** | L1, L 2, L3, L4 |
| **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. | **10** | L2, L3, L4 |
| **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. | **10** | L2, L3, L4, L6 |
| **MODULE – 4** | | |

| | | |
|---|---|---|
| **KINETIC MODELING FOR BIOSENSORS:** The purpose and practice of modeling; The flux equations, The flux diagram for the membrane/enzyme/electrode, Deriving a complete kinetic model; Kinetic modeling in other types of biosensors- Potentiometric enzyme electrodes, Optical and photometric biosensors. | **10** | L3, L4. L5 |
| **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. | **10** | L3, L4. L5 |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT BOOK**

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

**REFRENCE BOOKS**

1. Turner A.P.F, Karube.I and Wilson,G.S, Biosensors Fundamentals and applications, Oxford Univ. Press, 1990.
2. John H. Seinfeld and Leon Lapidus., Mathematical Methods in Chemical Engg., (Vol.3), Process Modeling, Estimations and Identification. Prentice Hall, 1974.
3. Shyam S. Sablani., Handbook of Food and Bioprocess Modeling Techniques. C R C

## NANOTECHNOLOGY AND ITS APPLICATION IN BIOPROCESS INDUSTRIES

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE253 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **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. | **10** | L1, L2 |
| **MODULE – 2** | | |
| **PROPERTIES OF INDIVIDUAL NANOPARTICLES:** Metal nanoclusters, Semiconducting nanoparticles, Rare gas and molecular clusters, methods of synthesis- RF Plasma, Chemical Methods, Thermolysis, Pulsed Laser methods. Carbon nanostructures: Carbonmolecule, Clusters, Carbon nanotubes, Applications. Bulk nanostructured materials: Solid disordered anostructures, nanostructure crystals | **10** | L1, L 2, L3, |
| **MODULE – 3** | | |
| **NANOSTRUCTURED FERROMAGNETISM:** Basics of ferromagnetism, Effect of bulk nanostructuring of magnetic properties, dynamics of nanomagnets. nanostrucures in zeolite cage. Quantum wells, wires and dots: Preparation of quantum nanostructures, Single electron tunneling, Applications. Catalysis: Nature of catalysis, Surface area of nanoparticles, porous materials, | **10** | L 2, L3, L4 |

| | | |
|---|---|---|
| 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**.** | **10** | L3, L4. |
| **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. | **10** | L3, L4. |

**Course outcomes:**

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

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT 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 BOOKS**


- Nanotechnology by Greggory Timp (Ed) Spring
- Nanotechnology by M. Karkere IK international publication
- Biological molecules in Nanotechnology by Stephen lee and Lynn M Savage
- Nanotechnology-A gentle Introduction to Next big Idea, Mark Ratner and Daniel Ratner
- Application of Nanotechnology in drug delivery. 2014, by Ali Demir
- CNR Rao, Nanoworld- An introduction to science and technology, JNCASR, Bangalore, 2010.

## DOWNSTREAM PROCESSING LABORATORY

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCEL26 | CIE Marks : | 40 |
| Hours/week : | 01 Hr Tutorial (Instructions) + 03 Hours Laboratory | Exam Hrs. : | 3 |
| Total Hours : | 48 | SEE Marks : | 60 |

**CREDITS – 02**

**Course objectives:**
Students will
1. Understand the nature of the end product, its concentration, stability and degree of purification required
2. Recover and subsequent purification of target biological products.

| SL NO | LABOATORY EXPERIMENTS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **1.** | Coagulation Jar Test | **L3, L4, L5** |
| **2.** | Effect of Temperature on enzyme activity | **L1, L4, L4** |
| **3.** | Aqueous two phase extraction | **L3, L4, L5** |
| **4.** | SDS PAGE Electrophores | **L3, L4, L5** |
| **5.** | Leaf filter | **L3, L4, L5** |
| **6.** | Ion exchange Chromatography | **L2, L3, L4** |
| **7.** | Simple Distillation | **L1, L2, L4** |
| **8.** | Ammonium sulphate precipitation | **L1, L4, L5** |
| **9.** | Single stage leaching | **L3, L4, L5** |

**Course outcomes:**
After studying this course, students will be able to:
1. Apply downstream processing opertions.
2. Determine appropriate operating ranges and scale-up parameters for downstream processing steps
3. Perform basic scale-up calculations for downstream unit operations

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

**Conduct of Practical Examination:**

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

**REFERENCE BOOKS**


- J.C. Janson And L. Ryden, (Ed.) – Protein Purificat ion – Principles, High Resolution Methods And Applications, VCH Pub. 1989.
- P.A. Belter, E.L. Cussler And Wei-Houhu – Biosepara tions – Downstream Processing For Biotechnology, Wiley Interscience Pun. (1988).
- R.O. Jenkins, (Ed.) – Product Recovery In Bioproces s Technology – Biotechnology By Open Learning Series, Butterworth-Heinemann (1992).


## TECHNICAL SEMINAR

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE27 | CIE Marks : | 100 |

**CREDITS – 02**

| BIOENERGY<br>[As per Choice Based Credit System (CBCS) scheme]<br>SEMESTER – III | | | |
|---|---|---|---|
| Sub. Code : | 18BCE31 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |
| **CREDITS – 04** | | | |

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **BIOENERGY RESOURCES:** Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification. Chemical composition and properties of different biomass materials and bio-fuels, Structural properties, Physical properties, properties of microbial biomass, Biomass resource assessment. Energy plantations -Preparation of woody biomass: Size reduction, Briquetting of loose biomass, Drying, Storage and Handling of Biomass, hydrogen production and biological fuel cell. | **10** | L1, L2 |
| **MODULE – 2** | | |
| **ETHANOL**: Biomass constituent to liquid fuels, liquid fuel alcohol from sugar cane molasses, sweet sorghum, and other sources like corn and lignocelluloses. Lignocelluloses ethanol production technologies, conversion. Corn ethanol production technologies, chemistry of ethanol fermentation, by products from fermentation process. | **10** | L1, L2 |
| **MODULE – 3** | | |
| **BIODESIEL**: Defination and properties of biodiesel Properties of Biodiesel, Catalyst used for biodiesel production. Biofuels from vegetable oil: production of vegetable oil, composition, process of extraction of | **10** | L1, L2 |

| | | |
|---|---|---|
| vegetable oil, applications. Trans-Esterification of Oils to produce Bio- Diesel. Biofuels from algae: Microalgae growth, algae harvesting, extraction and utilization of liquid biofuels. | | |
| **MODULE – 4** | | |
| **BIOGAS TECHNOLOGY:** Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, animal residues-. Microbial and biochemical aspects- Operating parameters for biogas production Kinetics and mechanism - Dry and wet fermentation. Digesters for rural application-High rate digesters for industrial waste water treatment. | **10** | L2, L3. |
| **MODULE – 5** | | |
| **PYROLYSIS AND GASIFICATION OF BIOMASS:** Biomass conversion routes, biomass densification technologies, biomass combustion of woody biomass. Biomass pyrolysis, cogeneration in biomass Processing Industries. Guidelines for designing downdraft gasifiers. Pyrolysis of biomass-Pyrolysis regime, effect of particle size, temperature, and products obtained. Thermo-chemical gasification principles: Effect of pressure, temperature and of introducing steam and oxygen. Design and operation of Fixed and Fluidized Bed Gasifiers. | **10** | L1, L2. L3 |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

1. Critical Thinking
2. Problem solving

**Question paper pattern:**

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

**TEXT 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 –princi ples and practice*, TERI Press, New Delhi, 2010.

**REFERENCE BOOKS**

*1.* Caye M. Drapcho, N.P. Nhuan and T. H. Walker, *Biofuels Engineering Process Technology* , McGraw Hill Publishers, New York, 2008.

*2.* Jonathan R.M, *Biofuels – Methods and Protocols (Methods in Molecu lar Biology Series)*, Humana Press, New York, 2009.

*3.* Lisbeth Olsson (Ed.), *Biofuels (Advances in Biochemical Engineering/Biotechnology Series*, Springer-Verlag Publishers, Berlin, 2007.

*4.* G D Rai, *Nonconventional Energy Sources*, Khanna Publications, 4th Edition, 2010.

# QC, QA & VALIDATION

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE32 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

**Course objectives:** This course will enable students to learn

- Appreciate the Basic concepts of Quality Control and Validation techniques for Biotechnology product development
- To understand and apply the different QC and QA methodologies.

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **QUALITY CONTROL AND ASSURANCE TECHNIQUE:** Introduction, Basis concepts of Quality:- Developing quality culture. Quality Assurance General Concepts: Definition of quality assurance concept and components of Q. A., Concept of Quality control, Quality control of Biological products: International Biological standards, safety testing of pharmaceutical Quality control of antibiotics. International, Japanese, British and Indian pharmacopeias. Current GMP in manufacturing, processing, packaging of drugs. GMP for finished products. | **10** | L1, L 2, L3, L4 |
| **MODULE – 2** | | |
| **GOOD LABORATORY PRACTICE:** Current GLP in manufacturing, responsibilities. General provision, organization and personnel, building and facilities, equipment, control of components and drug product, laboratory and control of records and reports, Non-clinical testing, Controls on animal house, Application of Computers in Quality control Laboratory. | **10** | L1, L 2, L3, L4 |
| **MODULE – 3** | | |
| **MANUFACTURING OPERATIONS AND CONTROL:** Revised schedule M, sanitation of manufacturing premises, Mix –ups and cross contamination, processing of intermediates and Bulk product, Packaging operations, I.P.Q.C., Release of finished products process deviations, Drug product inspection, expiration dating, Document and formats, Specification, Master production and control record, Batch production and control record Significance of SOPs and record, change control, Drug Master file | **10** | L 2, L3, L4 |

| | | |
|---|---|---|
| **MODULE – 4** | | |
| **INTRODUCTION TO PHARMACEUTICAL VALIDATION:**<br>Definition, Manufacturing Process Model, Government regulation, scope of Validation, Advantage of Validation, Organizations for Validation, Validation Master plan, URS, D.Q., IQ, OQ & P.Q. of facilities. **,** General principles of analytical method validation, Validation of HPLC , Dissolution test apparatus Process Validation **:** Prospective, concurrent, retrospective & revalidation, Process validation of formulations. Validation of Pharmaceutical Water System & pure steam, Validation of HAVC system, Validation of Compressed air, Cleaning of Equipment, Cleaning of Facilities, **Vendor Certification** | **10** | L3, L4. L5 |
| **MODULE – 5** | | |
| **DRUG REGULATORY AFFAIRS:**<br>Harmonization of regulatory requirements including ICH activity. Regulatory requirements of different regions applicable to pharmaceutical developments, manufacturing, quality control on finished products, extended release products, biopharmaceutical and bioequivalence assessment and good clinical practices and Comparison with regulation in India. Filing of INDA, NDA and ANDA for approval and registration. | **10** | L3, L4. L5 |

**Course outcomes:**

After studying this course, students will be able to:

- Demonstrate strong basics in principles of QA and QC
- Demonstrate the ability to use validation techniques and tools for product development.

**Graduate Attributes (as per NBA):**

- Problem Analysis
- Design / development of solutions.
- Professional Ethics

**Question paper pattern:**

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

**TEXT BOOKS**


- Pharmaceutical Quality Assurance, MA Potdar, Nirali Prakashan, Pune
- Validation of Pharmaceutical process, F. J. Carleton and J. Agalloco, Marcel Dekker Inc.
- Pharmaceutical Process Validation, Second Ed., Ira R. Ferry & Robert Nash., Marcel Dekker Inc.
- Quality Planning & Analysis by J. M. Juran and F. M. Gryna, Tata Mcgraw Hill, India.
- Improving Quality through Planned experimentation by Moen, Tata Mcgraw Hill.

**REFERENCE BOOKS**


- Good Manufacturing Practices for Pharmaceutical; A Plan for total Quality Control, 4th Ed, Sidney willing.
- Quality Assurance Guide by Organization of Pharmaceutical producers of India.
- Pharmaceutical Process Validation; By F. R., Berory and Robert A. Nash
- Impurities Evaluation of Pharmaceutical; Satinder Ahiya Marcel Decker.

# BIOLOGICAL WASTE TREATMENT

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE331 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **INTRODUCTION:** Objectives of wastewater treatment. Flow measurements and Composition. Characterization - Properties and analysis of wastewater, Problems on wastewater characterizations. Waste-water treatability studies-a bench scale and pilot scale. Effluent standards for discharge to water bodies and land applications- state and central | **10** | L1, L2 |
| **MODULE – 2** | | |
| Physical and Chemical treatment of wastewater: Screens, Comminutes, Grit chambers, Flow equalizations, Sedimentation, Flotation, Granular medium filtration Chemical treatment: chemical precipitation, Adsorption, Disinfection with chlorine, ozone, Ultraviolet light etc. Treatment disposal of sludge – Sludge characteristi cs, concentration. Aerobic/Anaerobic sludge digestion, sludge conditioning, Dewatering and drying. Incineration and wet oxidation. | **10** | L1, L2 |
| **MODULE – 3** | | |
| Microbiology of waste treatment – Growth and inhibi tion 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 | **10** | L3, L4 |

| | | |
|---|---|---|
| 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 | **10** | L3, L4 |
| **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. | **10** | L2, L3. L4 |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

- Critical Thinking
- Problem solving
- Ethical practices and social resposibility

**Question paper pattern:**

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

**TEXT BOOKS:**

1. 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<br>[As per Choice Based Credit System (CBCS) scheme]<br>SEMESTER – III | | | |
|---|---|---|---|
| Sub. Code : | 18BCE332 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |
| **CREDITS – 04** | | | |

**Course objectives:**
Students Will
1. Apply the basic concepts of thermodynamics like heat, enthalpy, internal energy, work, energy and power etc.
2. Study the laws of thermodynamics and their applications to biological systems.

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **FRONTIER OF BIOLOGICAL THERMODYNAMICS:** Energy conservation in living organism, Irreversibility and life, third law and biology, entropy and protein stability, Energy, information processing and life, second law and evolution, Gibbs free energy, Equilibrium concepts for biological thermodynamics. | **10** | L1, L2 |
| **MODULE – 2** | | |
| **FUNDAMENTAL CONCEPTS OF THERMODYNAMICS:** System and Surroundings, First law of thermodynamics -Internal energy, enthalpy, Heat Capacity, applied examples from biochemistry | **10** | L1, L2, L3 |
| **MODULE – 3** | | |
| **ENTROPY:** Second law – Entropy and universe, Concept of heat engines, protein stability and calorimetric measurements. Fundamentals of Differential scanning calorimeter and Isothermal calorimeter in biological property measurements, Third law of thermodynamics, Maxwell equations, Gibbs-Duhem Equation and the Phase Rule, Legendre Transforms. | **10** | L3 |
| **MODULE – 4** | | |
| **GIBBS FREE ENERGY AND ITS APPLICATIONS:** Gibbs free energy and equilibrium, Chemical potential, ionic solutions, Equilibrium constant, standard state in biochemistry, Acid and bases, chemical coupling and redox reactions, Gibbs free energy in photosynthesis, glycolysis citric acid cycle, Oxidative phosphorylation and ATP | **10** | L3, L4 |

| | | |
|---|---|---|
| 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, contraction and the molecular motors. | **10** L3 | polymerisation, muscle |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT BOOK**

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

**REFERENCE BOOK**

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

**FERMENTATION TECHNOLOGY**
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – III

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE333 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| **INTRODUCTION TO FERMENTATION PROCESSES:** The range of fermentation Processes: Microbial Biomass, Enzymes, Metabolites and Transformation Processes; Development of fermentation Industry; Components of Fermentation Process; **Microbial Growth Kinetics – A Review:** Batch Culture; Continuous Culture; Fed-batch Culture; Applications. | **10** | L1, L2 |
| **MODULE – 2** | | |
| **ISOLATION, PRESERVATION AND IMPROVEMENT OF INDUSTRIAL MICROORGANISMS:** Isolation Methods utilizing the selection of desired characteristics; Isolation Methods not utilizing the selection of desired characteristics; Preservation Methods: At Low temperature, Dehydration, and their quality control; The selection and Isolation of induced mutants improving yields of secondary metabolites; Use of recombinant systems for the improvement of industrial microorganisms. | **10** | L2, L3 |
| **MODULE – 3** | | |

| | | |
|---|---|---|
| **MEDIA FOR INDUSTRIAL FERMENTATIONS:** Typical Media and formulation; Sources of Energy, Carbon, Nitrogen, Minerals, vitamins, precursors, Oxygen and others. **Sterilization of Media:** Medium Sterilization; Design of Batch and Continuous Sterilization; Sterilization of Fermenter, Feed, Air; Filtration of Air and Design of Filters**;** **Development of Inocula For Industrial Fermentations:** The development of Inocula for yeast, bacterial, fungal and streptomycete processes; Aseptic inoculation of plant Fermenters | **10** | L3 |
| **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. | **10** | L3, L4 |
| **MODULE – 5** | | |
| **RECOVERY AND PURIFICATION OF FERMENTATION PRODUCTS: A REVIEW:** Filtration, Centrifugation, Cell Disruption, Extraction, Chromatography, Ultra filtration, Drying, Crystallization and Whole broth processing; **Effluent Treatment:** Strength of fermentation effluents; Disposal Methods; Treatment processes: Aerobic and Anaerobic; Byproducts; | **10** | L3 |
| **Course outcomes:**<br>After studying this course, students will be able to:<br>1. to devise the isolation and improvement methods base on metabolic pathway of the product<br>2. design, formulate and sterilize the media for different inocula on large scale<br>3. to understand design and operation of basic control loops with respect to fermentation process | | |
| **Graduate Attributes**<br>1. Critical Thinking<br>2. Problem solving<br>3. Use of modern tools<br>4. Research Skill<br>5. Life-long learning | | |
| **Question paper pattern:**<br>• The question paper will have ten questions.<br>• Each full question consists of 16 marks.<br>• There will be 2full questions (with a maximum of four sub questions) from each module.<br>• Each full question will have sub questions covering all the topics under a module. | | |

- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOK**

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

**REFERENCE BOOKS:**

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

## ANIMAL CELL CULTURE & TISSUE ENGINEERING

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

| | | | |
|---|---|---|---|
| Sub. Code : | 18BCE334 | CIE Marks : | 40 |
| Hours/week : | 4 | Exam Hrs. : | 3 |
| Total Hours : | 50 | SEE Marks : | 60 |

**CREDITS – 04**

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

| MODULES | TEACHING HOURS | REVISED BLOOM'S TAXONOMY (RBT) LEVEL |
|---|---|---|
| **MODULE – 1** | | |
| Characteristics of animal cell, metabolism, regulation and nutritional requirement. Effects of shear force and kinetics of cell growth and product formation. Product and substrate transportation | **10** | L1, L2 |
| **MODULE – 2** | | |
| Hybridoma technology; genetic engineering in animal cell culture; scale-up and large scale operation; Perfusion bioreactors, hollow fiber bioreactor, operational strategies of mass cell culture. | **10** | L1, L3 |
| **MODULE – 3** | | |
| Disaggregation (enzymatic and mechanical) of tissue and primary culture; Cultured cells and evolution of cell lines; Maintenance of cultures – cell lines; Clonin g of cell lines; Large scale cell cultures in biotechnology ; Somatic cell fusion | **10** | L1, L4 |
| **MODULE – 4** | | |
| Culture media (Preparation and sterilization), Harvesting, selection and expansion. Differentiation, Change of phenotype. Cryopreservation. Tissue, organ and organotypic cultures. Mass transport and nutrition gradients in tissue engineering ($O_2$) as model. Cryopreservation of organs and ECM Freezing and vitrification. Most common Bioreactors in Tissue | **10** | L1, L2 |

| | | |
|---|---|---|
| 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. | **10** | L1, L2 |

**Course outcomes:**

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

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

**Graduate Attributes**

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

**Question paper pattern:**

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

**TEXT BOOKS**

1. 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.

| EVALUATION OF PROJECT PHASE -1<br>[As per Choice Based Credit System (CBCS) scheme]<br>SEMESTER – III | | | |
|---|---|---|---|
| Sub. Code : | 18BCE34 | CIE Marks : | 100 |
| Hours/week : | 2 | Exam Hrs. : | - |
| Total Hours : | 25 | Exam Marks : | - |
| **CREDITS – 02** | | | |

| INTERNSHIP<br>[As per Choice Based Credit System (CBCS) scheme]<br>SEMESTER – III | | | |
|---|---|---|---|
| Sub. Code : | 18BCEI35 | CIE Marks : | 40 |
| Hours/week : | - | Exam Hrs. : | 3 |
| Total Hours : | - | SEE Marks : | 60 |
| **CREDITS – 06** | | | |

| PROJECT WORK PHASE -2<br>[As per Choice Based Credit System (CBCS) scheme]<br>SEMESTER – IV | | | |
|---|---|---|---|
| Sub. Code : | 18BCE41 | CIE Marks : | 40 |
| Hours/week : | - | Exam Hrs. : | 3 |
| Total Hours : | - | SEE Marks : | 60 |
| **CREDITS – 20** | | | |