

**School of Biochemical Engineering  
Institute of Technology  
BANARAS HINDU UNIVERSITY  
VARANASI - 221005**

**Revised Course Structure for M.Tech in Biochemical Engineering**  
**(Session 2007 – 2008 Onwards)**

**Semester I**

	<b><u>Theory:</u></b>	Contact Hrs./Week	Credits
BC 5101	Microbiological Engineering	3	3
BC 5102	Fundamentals of Microbiology & Biochemistry	3	3
BC 5103	Bioprocess Technology	3	3
	Elective I (Departmental Course)	3	3
	Elective II (Departmental Course)	3	3
	<b>Any one of the following (BC 5106 or BC 5107)</b>		
BC 5106	Mathematics for Biologists	3	3
BC 5107	Biology for Engineers	3	3
	<b><u>Practical:</u></b>		
BC 5301	Biochemical Engineering Laboratory I	6	4
<b>Semester I Total</b>		<b>24</b>	<b>22</b>

**Semester II**

	<b><u>Theory:</u></b>		
	Open Elective (From other departments)	3	3
	Elective III	3	3
	Elective IV	3	3
	Elective V	3	3
	Elective VI	3	3
	<b><u>Practical:</u></b>		
BC 5401	Biochemical Engineering Laboratory II	3	2
BC 5402	Seminar	2	1
BC 5403	Project	3	2
<b>Semester II Total</b>		<b>23</b>	<b>20</b>

**Semester III**

BC 6101	Seminar on Dissertation		5
BC 6102	Dissertation – Interim Evaluation		5
<b>Semester III Total</b>			<b>10</b>

**Semester IV**

BC 6201	Dissertation - Open defense		5
BC 6202	Dissertation - Evaluation		10
<b>Semester IV Total</b>			<b>15</b>
<b>Course Total</b>			<b>67</b>

## **LIST OF ELECTIVES**

### **Elective I and II**

*Any **Two** from the following:*

1. BC 5111 Environmental Biotechnology
2. BC 5112 Bioprocess Instrumentation & Control
3. BC 5113 Bioinformatics
4. BC 5114 Enzyme Engineering and Technology
5. BC 5115 Computer application & Biostatistics

### **Elective III, IV, V & VI**

*Any **Four** from the following:*

1. BC 5211 Transport Phenomena in Microbial Systems
2. BC 5212 Bioreactor Design
3. BC 5213 Downstream Processing
4. BC 5214 Food Science & Engineering
5. BC 5215 Advanced Fermentation Technology
6. BC 5216 Genetic Engineering
7. BC 5217 Modeling & Simulation of Bioprocesses
8. BC 5218 Bioconversion
9. BC 5219 Biological Wastewater Treatment
10. BC 5220 Bioprocess Plant Design

## **SYLLABUS**

### **BC 5101 : Microbiological Engineering**

Microbial growth; Aerobic and anaerobic growth phenomena; Synchronous culture; Mathematical modeling of microbial growth; Product synthesis kinetics; Batch, fed-batch and continuous culture cultivation techniques; Growth and non-growth associated product formation; Principles and mechanism of media sterilization – Thermal and membrane filtration; Batch and continuous sterilization of media; Air sterilization - Principles and design; Characteristics of biological fluids.

### **BC 5102 : Fundamentals of Microbiology & Biochemistry**

Isolation, identification and preservation of industrial microorganisms; Physiology and morphology of bacteria, yeast and fungi; Characteristics of viruses; Bioenergetics of metabolic pathways; Elementary mass balance; Energy balance; ATP generation and  $Y_{ATP}$ , Energy yielding and consuming metabolic pathway; Detoxification of Xenobiotic compound; Steroid transformation.

### **BC 5103 : Bioprocess Technology**

Industrial importance of microorganism; Alcoholic fermentation - ethyl alcohol, wine and beer; Baker's yeast production; Production of glycerol, Acetone, and butanol; Microbial production of organic acids -citric acid, gluconic acid, itaconic acid, gibberellic acid, lactic acid, and vinegar; Production of industrial enzymes - amylases, proteases, cellulases, invertases, pectinases; Production of antibiotics - penicillin, semi synthetic penicillin, streptomycin, tetracycline's; Mushroom production

### **BC 5111 : Environmental Biotechnology**

Components of environment; Environmental pollutions, its measurements and management; Air pollution and its control through biotechnology; Water pollution and its control; Microbiology of waste water treatment – Aerobic and anaerobic processes, Treatment scheme for domestic and industrial waste water; Microbial degradation of Xenobiotics compounds; Pesticides and pest management through biological processes; Solid wastes and management; Bioremediation of contaminated soils and waste land; Global environmental problems – Ozone depletion, Green house effect, Acid rain and Global warming, their impact and biotechnological approaches for management; Environmental acts and regulations.

### **BC 5112 : Bioprocess Instrumentation & Control**

Biochemical process variables and their measurements; Control principles and their application in bioreactors; Theory of electrode processes and their applications; Measurement and control of pH, temperature, dissolved oxygen, aeration and agitation, redox potential, foam, etc.; On-line analysis of process parameters; Introduction to biosensors; Transduction principles used in biosensors; Characteristics of biosensors; Biosensors based on amperometric, potentiometric, thermistor FET, fiber optics and bioluminescence; Microbial biosensors; Fundamentals of digital process control; Use of computer in control and optimization of microbiological processes.

### **BC 5113 : Bioinformatics**

Computers in biology and medicine; Internet, intranet and extranet; Networking protocols; Database management systems; Current trends in information technology; Genome analysis; Sequence analysis packages; Molecular biology software; Internet resources –Biomednet, Medline, Protein/Nucleic acid sequence; Prediction method based on protein sequences.

### **BC 5114 : Enzyme Engineering and Technology**

Sources and structure of enzyme; Biosynthesis, regulation and control of enzyme in microorganisms; Kinetics of enzymatic reaction, Single and multiple substrate systems, Inhibition - substrate, product and inhibitors, Analysis of kinetic data, Active and legend binding sites, Mechanism of enzyme action; Large scale production and purification of enzyme; Cofactors and their role in enzyme activity; Immobilization of enzyme and whole cells; Process design and operation strategies for immobilized enzyme reactors; External and diffusional mass transfer limitation, Effectiveness factor and modulus; Stabilization of enzyme, synzyme, Immobilization of multiple enzyme system; Protein engineering; Application of enzyme - Industrial, Analytical and Medical.

### **BC 5115 : Computer Applications & Biostatistics**

Data sets and its presentation; Measures of central tendency and dispersion; Significance tests; Regression analysis; Digital computer – Hardware and software, MS-DOS and WINDOW operating systems; Programming languages; Flow charts and Programming techniques; Introduction to programming in Basic, Fortran, C and C<sup>++</sup>; Introduction to data structure and database concepts; Introduction to WINDOW based Word processing, Spreadsheets and Presentation Software; Computer graphics; Software packages for solving mathematical and statistical problems; Internet and its applications.

### ***Audit Courses***

#### **BC 5106 : Mathematics for Biologists**

Basic differential and integral calculus, Differential equations and their solution; Laplace transform Bessel's and Legendre's function; Basic principles of statistics; Theory of probability; Curve fitting, Modern algebra, Linear programming, Boundary value problems, Numerical analysis.

#### **BC 5107 : Biology for Engineers**

Living cell - a micro reactor for the synthesis of variety of macromolecules, diversity of life species; Properties, organization and transformation of biomolecules; Regulatory and feedback control mechanism governing the biosynthesis and biodegradation reactions; Fundamentals of genetic engineering; Environmental response of cells biology and the future of man and his environment; Perpetual and massive synthesis of biomass, Structural and Functional genomics

#### **BC 5211 : Transport Phenomena in Microbial System**

Unified theory of momentum, energy and mass transfer; Flow and mixing of Newtonian and non-Newtonian fluids; Gas-liquid mass transfer in microbial systems; Oxygen transfer rates; Single and multiple bubble aeration; Design of spargers and aeration equipment; Mass transfer across free surface as well as freely rising or falling bodies; Basic concept of oxygen transfer coefficient ( $K_La$ ) and its measurement; Correlation of  $K_La$  with other operating variables; Factors affecting the  $K_La$ .

### **BC 5212 : Bioreactor Design**

Thermodynamics and rate concept of biological systems; Bioreactor configuration - batch, continuous stirred-tank, tubular, fluidized bed and the like; Kinetic expression; the Monod equation and its generalization; Bioreactor design and optimum operations – Mixing characteristics; Residence time distribution, Concentration distribution and Temperature distribution; Biological system parameters; Processes involving microbial flocs; Bioreactors containing microbial films; Basic concept of scale-up of bioreactors.

### **BC 5213 : Down Stream Processing:**

Characteristics of fermentation broth; Separation of cells and solid particles; Separation of charged particles; Cell disintegration - dynamill and ultrasonication; Protein precipitation; Product recovery and purification - Filtration, Ion exchange, Chromatography, Membrane separation, Electrophoresis, Affinity chromatography, Crystallization, Drying, Gel filtration, Cross filtration, Cascade separation, Dispersive separation, Adsorptive separation; Product recovery trains.

### **BC 5214 : Food Science and Engineering:**

Proximate composition of foods; characteristics and physiological functions of carbohydrates, proteins, lipids, vitamins, natural pigments and flavouring agents present in food; General introduction of food technology and food preservation; Preservation of food by application of heat; Food preservation by canning and heat removal technique; Cold storage and freezing including cryogenic freezing of food; Preservation of food by dehydration, preservatives, high osmotic pressures, antibiotics and radiation; Preservation of food by fermentation.

### **BC 5215 : Advanced Fermentation Technology:**

Selection and genetical improvement of industrial microorganisms; Chemistry and biosynthesis of antibiotics and vitamins, Metabolic regulations in industrial fermentation; Microbial production of amino acids - lysine, glutamic acids; Microbial production of antifungal antibiotics and broad spectrum antibiotics; Microbial transformation of steroids; Microbiological assay techniques and microbiological estimation of antibiotics and vitamins; Application of antibiotics in animal nutrition and food preservation; Mycotoxins and microbial insecticides; Large scale fermentation development of recombinant microorganisms.

### **BC 5216 : Genetic Engineering**

Gene structure and replication; Transcription, genetic code and translation; Biochemical genetics; Cloning strategies; Recombinant selection and characterization; Optimization of the expression of cloned gene, cloning vectors and hosts; DNA sequencing; Cloning of insulin gene; Cloning of other genes of commercial interest; Restriction-modification and discussion on enzymes important in genetics engineering; Alternative approaches; Future of genetic engineering.

### **BC 5217 : Modeling & Simulation of Bioprocesses**

Types of kinetic model; Data smoothing and analysis; Mathematical representation of bioprocess; Parameter estimation; Numerical integration techniques; Parameter sensitivity analysis; Statistical validity; Discrimination between two models; Physiological state markers and its use in the formulation of a structured model; Development of compartment and metabolic pathway models for intracellular state estimation; Dynamic simulation of batch, fed-batch steady and transient culture metabolism; Numerical optimization of bioprocess using mathematical models.

### **BC 5218 : Bioconversion**

Introduction, definition, objective and scope; Photosynthesis and its primary productivity in nature; Resources, composition and availability of biomass in India; Biomass refining by thermal, chemical and bioconversion systems and their net energy analysis; Environmental effects of biomass refining; Growth, harvesting; processing and utilization of algae and water hyacinth; Integrated bioconversion system approaches.

### **BC 5219 : Biological Wastewater Treatment**

Waste; Characterization of waste water; BOD progression curve and kinetics; Determination of BOD ; Kinetics of nitrification and denitrification; Treatment process for waste water; Kinetics of activated sludge process (ASP); Mixing regime in ASP; Aeration system; Loading criteria; Sludge viability; Solid-liquid separation; Primary and secondary clarifier; Anaerobic treatment of wastes; Kinetics of anaerobic treatment; Sludge characteristics; Process modeling and control; Case study.

### **BC 5220 : Bioprocess Plant Design**

Introduction; General design information; Mass and energy balance; Flowsheeting; Piping and instrumentation; Materials of construction for bioprocess plant; Mechanical design of process equipment; Vessels for biotechnology application; Design of bioreactors; Design considerations for maintaining sterility of process streams and process equipment; Selection and specification of major equipment used in bioprocess industries; Utilities for biotechnology production plants; Process economics; Bioprocess validation; Safety considerations; Case studies.