DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY
LUCKNOW

Evaluation Scheme & Syllabus
For

B.Tech. Fourth Year
(Biotechnology)

On

Choice Based Credit System
(Effective from the Session: 2019-20)

DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY LUCKNOW

Study and Evaluation Scheme
B.TECH. BIO-TECHNOLOGY
(Effective from the session: 2019-20)

4th Year, 7th Semester

S. No.	Subject Code	Subject Name	Teaching Deptt.	L-T-P	Th/Lab Marks	Sessional		Total	Credit
						Test	Assig/Att.		
1		Open Elective Course-I	Other Department	3-0-0	70	20	10	100	3
2	RBT071-074	Departmental Elective-III	Core Department	3-0-0	70	20	10	100	3
3	RBT075-078	Departmental Elective-IV	Core Department	3-1-0	70	20	10	100	4
4	RBT701	Environmental Biotechnology	Core Department	3-0-0	70	20	10	100	3
5	RBT702	Bioseperation & Down Stream Processing	Core Department	3-1-0	70	20	10	100	4
6	RBT751	Environmental Biotechnology Lab	Core Departmen	0-0-2	50		50	100	1
7	RBT752	Bioseperation & Down Stream Processing Lab	Core Department	0-0-2	50		50	100	1
8	RBT753	Industrial Training	Core Department					100	2
9	RBT754	Project-I	Core Department					200	3
	Total							**1000**	**24**

Departmental Elective-III

RBT071: Genomics and Proteomics

RBT072: Quality Control & Regulatory Affairs

RBT073: Clinical Trials & Management

RBT074: Bioprocess Economics & Project Management

Departmental Elective-IV

RBT075: Biosafety, Bioethics, IPR & Patents

RBT076: Agriculture Biotechnology

RBT077: Biomaterials

RBT078: Applications of Natural Products

RBT701: Environmental Biotechnology

L	T	P
3	0	0

Unit I

[8]

Environmental pollution: An overview, Land, water , air , and noise, Marine (introduction , sources , effects and measurements). Thermal Pollution, Nuclear and Radiation Pollution, Type of Radiation, Radioactivity in nature, Decay chains, Toxic Hydrocarbon, Radioactive waste sunk, Genetic Consequences.

Unit II

[8]

Biological waste treatments and biofuel production. Microbiology of waste water treatments Methanogenesis: methanogenic, acetogenic, and fermentative bacteria – anaerobic and aerobic digestion processes and conditions. Minimal national standards for waste disposal. .

Unit III

[8]

Principles and design aspects of various waste treatments methods, with advanced bioreactor configuration : activated sludge process , trickling filter, fluidized expanded bed reactor , upflow anaerobic sludge blanket reactor , contact process , fixed / packed bed reactor , hybrid reactor , sequential batch reactor .

Unit IV

[8]

Kinetic models for biological waste treatment :bioconversion of agricultural and other higly organic waste materials into gainfully utilizable products – biogas, H2, celluloses and food and feed stocks. Economical and social aspects of waste treatment.

Unit V

[8]

Bioremediation & Biomineralization: land , water ,Contaminated Soil, industries , organic contaminants , heavy metals. Bioconversion of cellulose, Hemicelluloses, Lignin (lignocelluloses), Bioleaching of ores, Recovery of metals.

Recommended Books:

1. Waste Water Engineering- Metcalf & Fuddy, 3rd ed.
2. Environmental Processes I-III, J. Winter, 2nd ed., Wiley Publications
3. Introduction to Waste Water Treatment- R. S. Ramalho, Academic Press.
4. Environmental Studies- Dwivedi & Mishra, Ed. 2007.
5. Environmental Biotechnology, B.C. Bhattacharya & Ritu Banerjee, Oxford Press, 2007.
6. Essentials of Ecology & Environmental Science, S.V.S. Rana, Prentic-Hall India, 2006.
7. Perspectives in Environmental Studies, Anubha Kaushik & C P Kaushik, New Age International Publishers, 2004.
8. Agarwal S.K. (1998), Environmental Biotechnology, APH Publishing Corporation, New Delhi.
9. Environmental Sciences – Purohit , Shammi & Agrawal, Student Edition 2004.

RBT702: Bioseperation & Down Stream Processing

L	T	P
3	1	0

UNIT I - INTRODUCTION TO BIOSEPARATION PROCESS

(8)

Role and importance of bioseparation in biotechnological processes: RIPP scheme, Problems and requirements of bioproducts purification - Properties of Biomolecules - Characteristics of fermentation broth - Biological activity, Analysis of purity-Process economics: Capital and operating cost analysis.

UNIT II - REMOVAL OF INSOUBLES

(8)

Cell disruption methods for intracellular products: Physical, chemical and mechanical - Removal of insolubles: Biomass and particulate debris separation techniques - flocculation - sedimentation - centrifugation and filtration methods.

UNIT III - ISOLATION OF PRODUCTS

(8)

Adsorption: Principles - Langumir - Freundlich isotherms - Extraction: Basics- Batch and continuous, aqueous two-phase extraction - supercritical extraction - *in situ* product removal - Precipitation: Methods of precipitation with salts - organic solvents and polymers - Membrane based separations: Micro and ultra filtration - theory - design and configuration of membrane separation equipments and its applications.

UNIT IV - PURIFICATION OF BIOPRODUCT

(8)

Basic principles of Chromatographic separations: GC-HPLC-gel permeation-ion-exchange-affinity- reverse phase and hydrophobic interaction chromatography-Electrophoretic separation techniques: capillary - isoelectric focusing-2D gel electrophoresis - Hybrid separation technologies: GC-MS and LC-MS.

UNIT V - PRODUCT POLISHING

(8)

Crystallization: Principles-Nucleation-Crystal growth-Kinetics-Batch crystallizers: Scale-up and design, Drying: Principles-Water in biological solids- Heat and mass transfer-Drying equipments: description and operation-Vacuum shelf - rotary dryer-Freeze dryer-Spray dryer. Biomolecules of Commercial importance Ethanol, citric acid, lysine, steroids, penicillin, dextran, trehalose, subtilisin, chymosin, vitamin B12, hepatitis B vaccine, insulin, erythropoietin, monoclonal antibodies.

TEXT BOOKS

1. Roger G. Harrison, Paul Todd, Scott R. Rudge, Demetri P. Petrides, "*Bio separation Science and Engineering*" Oxford University press, 2003.

2. Belter PA and Cussler E, "*Bioseparations*", Wiley, 1985.
3. Protein: Biochemistry and Biotechnology by Gary Walsh (2002 John Wiley & Sons Ltd.)
4. Process Biotechnology Fundamentals by S.N. Mukhopadhyay (2001). Viva Books Private Limited.
5. Schuler & Kargi, Bio-process Engg. PHI
6. Keith Wilson and John Walker, Practical Biochemistry—Principles and Techniques, Cambridge,
5th Ed.2000
7. Coulson & Richardson's Chemical Engineering – Volume 3 (Chemical and Biochemical Reactors
and process controls) ed. Richardson, J.F., Peacock, D.G., First Indian ed. Asian Books Pvt. Ltd. 1998.
8. Bailey & oils, Biochemical Engg. Fundamentals, McGraw-Hill, 1990
9. Geankoplis, C.J. Transport Processes and Unit Operations Prentice Hall of (I) 3rd ed. 1997.
10. Mukhopadhyay, S.N. Process Biotechnology Fundamentals, Viva Books Pvt. Ltd. 2001.
11. Muni & Cheryan, Handbook of Ultrafiltration

REFERENCES

1. Raja Ghosh, "*Principles of Bioseparations Engineering*", World Scientific Publishing, 2006.
2. Ladisch.M.R, "*Bioseparation Engineering: Principles, Practice and Economics*", John Wiley &
sons, New York, 2001.
3. Asenjo.J.M, "*Separation processes in Biotechnology*" Marcel Dekker Inc.1993.

RBT071: Genomics and Proteomics

L	T	P
3	0	0

Unit I [10]

Introduction Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNA-mitochondrial, chloroplast; DNA sequencing-principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis-physical and genetic mapping.

Unit II [8]

Genome sequencing projects Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, EST's and SNP's.

Unit III [8]

Proteomics Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution isoelectricfocusing;

Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid system.

Unit IV [6]

Pharmacogenetics High throughput screening in genome for drug discovery-identification of gene targets, Pharmacogenetics and drug development

Unit V [8]

Functional genomics and proteomics Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein in situ arrays; Structural proteomics

Texts/References :

1. Voet D, Voet JG & Pratt CW, Fundamentals of Biochemistry, 2nd ed. Wiley 2006
2. Brown TA, Genomes, 3rd ed. Garland Science 2006
3. Campbell AM & Heyer LJ, Discovering Genomics, Proteomics and Bioinformatics, 2nd ed. Benjamin Cummings 2007
4. Primrose S & Twyman R, Principles of Gene Manipulation and Genomics, 7th ed, Blackwell [2006].
5. Glick BR & Pasternak JJ, Molecular Biotechnology, 3rd ed, ASM Press [1998]

RBT072: Quality Control & Regulatory Affairs

L	T	P
3	0	0

Unit I **[8]**

Concept and evolution of quality control and quality assurance. Quality control laboratory responsibilities: GLP protocols on non-clinical testing control on animal house, data generation, integration and storage, standard test procedure, retention of sample records. CPCSEA guidelines.

Unit II **[8]**

Quality review and batch release document of finished products, annual product quality review and parametric release, Audits, quality audits of manufacturing processes and facilities, audits of quality control.

Unit III **[8]**

Good documentation practices, route cause analysis, corrective action preventive action (CAPA), out of specifications (OOS) and out of trend (OOT), Clinical studies- ICH GCP (E6) guidelines, post marketing surveillance, Pharmacovigilance

Unit IV **[8]**

BABE (bioavailability and bioequivalence) studies, Concepts and management of contract manufacturing guidelines, Statistical Tools for Quality Control and Precision, Tools of Problem Solving and Continuous Improvement

Unit V **[8]**

Introduction, scope and importance of IPR, Concept of trade mark, copyright and patents Product registration guidelines – CDSCO, USFDA, Concept of ISO 9001:2008, 14000, OSHAS guidelines, Quality Strategy for Indian Industry, Brief concept of IND, NDA, ANDA, SNDA and PAT.

References:

1. Sharp J. Good Pharmaceutical Manufacturing Practice: Rationale and Compliance. CRC Press; 2005.
2. Chow SC. Encyclopedia of Biopharmaceutical Statistics. Marcel Dekker; 2003. Page 6 of 16
3. McCormick K. Quality (Pharmaceutical Engineering Series). Butterworth-Heinemann; 2002.
4. Gad SC. Pharmaceutical Manufacturing Handbook: Production and Processes. John Wiley & Sons; 2008.
5. Willig SH, Stoker JR. Good manufacturing practices for pharmaceuticals: a plan for total quality control. Marcel Dekker; 1997.
6. Signore AA, Jacobs T. Good Design Practices for GMP Pharmaceutical Facilities. Taylor &Francis Group; 2005.
7. Sarker DK. Quality Systems and Controls for Pharmaceuticals. John Wiley & Sons; 2008.
8. Haider SI. Pharmaceutical Master Validation Plan: The Ultimate Guide to FDA, GMP, and GLP Compliance. St. Lucie Press; 2002.
9. Steinborn L. GMP/ISO Quality Audit Manual for Healthcare Manufacturers and Their Suppliers, Sixth Edition, (Volume 1 - With Checklists and Software Package). Taylor & Francis; 2003.
10. Kolman J, Meng P, Scott G. Good Clinical Practice: Standard Operating Procedures for Clinical Researchers. Wiley; 1998.

RBT073: Clinical Trials & Management

L	T	P
3	0	0

Unit-I **[8]**

General Introduction - Good Clinical Practices, Basics Of Drug Development - Basic Principles of Drug discovery & Development, Stages of Drug Discovery. Research for a new drug. Preclinical Research, Pharmacokinetics & Drug Disposition

Unit-II **[8]**

Ethics In Clinical Research - Ethical issues in the conduct of clinical trials in India, Readiness of ethics committees, Independence of ethics committees, Training for ethics committee members. Informed consent process.

Unit-III **[8]**

Regulatory Affairs In Clinical Research - Roles & Responsibilities, Pharmacovigilance researching, assessing and evaluating information from healthcare providers and patients. Pharmacovigilance is particularly concerned with adverse drug reactions. Adequacy of regulations to safeguard the clinical trial participants.

Unit-IV **[8]**

Essential Documents & Regulatory Submission, Compliance And Audits - preparation, production and quality control of regulatory documents, creating editorial timelines and work flow specifications, scheduling and tracking documents, writing and proofreading. Development and updates on specifications for the design, tracking of regulatory documents and artwork used in regulatory documents.

Unit-V **[8]**

Clinical Trial Monitoring - Fundamentals of Clinical Monitoring, the processes and procedures of monitoring a clinical trial, Clinical, Pharmacological (including pharmacodynamics and pharmacokinetic) or adverse Effects with the objective of determining safety and efficacy of the new drug. Clinical Data Management And Biostatistics – establishment of protocol-specific data review and entry guidelines to document data validation and formatting procedures.

RBT074: Bioprocess Economics and Project Management

L	T	P
3	0	0

UNIT I [8]

Introduction to statistical process control and capability analysis: Chance and assignable cause of quality variation, Statistical basis of process monitoring: control chart, choice of control charts, analysis of control chart, variable of control charts, X bar and R chart, Attribute control chart, Determining process and measurement capability

UNIT II [8]

DOE Approach to Medium Optimization: - traditional (linear) approach (OFAT) and multi-dimensional approach (Box-Bhenken Design, central composite design, Plackett-Burman Design, Downhill Method, Full factorial, Fractional factorial,);

UNIT III [8]

Introduction: Meaning, Nature and Scope of Economics, Meaning of Science, Engineering and Technology Managerial Economics and its scope in engineering perspective. Basic Concepts Demand Analysis, Law of Demand, Determinates of Demand, Elasticity of Demand-Price, and Income and cross Elasticity .Uses of concept of elasticity of demand in managerial decision

UNIT IV [8]

Demand forecasting: Meaning, significance and methods of demand forecasting, production function, Laws of returns to scale & Law of diminishing returns scale. An overview of Short and Long run cost curves – fixed cost, variable cost, average cost, marginal cost, Opportunity cost.

UNIT V [8]

Introduction: Concept, Development, application and scope of Industrial Management. Management Function: Principles Production requirements. Productivity: Definition, measurement, productivity index, types of production system, Industrial of Management- Management Tools – time and motion study, work simplification- process charts and flow diagrams, Production Planning, Specification of Ownership.

Text/Reference Books:

1. Douglas C Montgomery: Statistical Quality Control
2. Managerial Economics for Engineering: Prof. D.N. Kakkar
3. T.R. Banga: Industrial Engineering and Management
4. Managerial Economics: Maheshwari.
5. Khanna O.P.: Industrial Engineering

Departmental Elective-IV

RBT075: BIOSAFETY, BIOETHICS, IPR &PATENTS **L T P**
3 1 0

Unit 1: BIOSAFETY-REGULATORY FRAMEWORK FOR GMOS IN INDIA Regulatory framework in India governing GMOs-Recombinant DNA Advisory Committee (RDAC), Institutional Biosafety Committee (IBC), Review Committee on Genetic Manipulation, Genetic Engineering Approval Committee (GEAC), State Biosafety Coordination Committee (SBCC), District Level Committee (DLC). Recombinant DNA Guidelines (1990), Revised Guidelines for Research in Transgenic Plants (1998), Seed Policy (2002), Prevention Food Adulteration Act (1955), The Food Safety and Standards Bill (2005), Plant Quarantine Order (2003), Regulation for Import of GM Products Under Foreign Trade Policy (2006-2007), National Environment Policy (2006). Rules for the manufacture, use/import/export and storage of hazardous microorganisms/genetically engineered organisms or cells (Ministry of Environment and Forests Notification, (1989).

Unit 2: BIOSAFETY-REGULATORY FRAMEWORK FOR GMOS AT INTERNATIONAL LEVEL Convention of Biological Diversity (1992) – Cartagena Protocol on Biosafety – Objectives and salient features of Cartagena Protocol – Advanced Information Agreement (AIA) procedure – procedures for GMOs intended for direct use-risk assessment-risk management-handling, transport, packaging and identification of GMOs- Biosafety Clearing House-unintentional transboundary

movement of GMOs-Benefits of becoming a party to the Cartagena Protocol- status of implementation in India.

Unit3: BIOETHICS Distinction among various forms of IPR, ,Prior art for a patent, Patenting live microorganism, Human Genome project and ethical issues, Animal cloning, human cloning and their ethical issues, Experimenting on animals. Public education of producing transgenic organism, legal and socioeconomic impacts of biotechnology, testing drugs on human volunteers, Hazardous materials used in biotechnology, their handling and disposal.

Unit 4: INTELLECTUAL PROPERTY RIGHTS Concept of property, rights, duties and Jurisprudential definition, Introduction to patent, copy right, trademarks, Design, geographical indication. History and evolution of IPR, Economic importance of IPR, Indian patent act 1970 (amendment 2000), Distinction among various forms of IPR, invention step, biopiracry and bioprospecting- Appropriate case studies. Infringement/violation of patent, remedies against infringement (civil, criminal, administrative)

Unit 5: PATENTS AND PATENT LAWS Plant and Animal growers rights patents trade secrets, and plant genetic recourses GATT and TRIPS, Dunkels Draft Patenting of biological materials, Current Issues of Patents for higher animal and higher plants, patenting of transgenic organisms, isolated genes and DNA sequences.

REFERENCES:

1. Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.
2. Intellectual property rights and Bio-Technology (Biosafety and Bioethics), Anupam Singh, Ashwani Singh, NPH, New Delhi
3. Sasson A, Biotechnologies and Development, UNESCOPublications.
4. Singh K, Intellectual Property rights on Biotechnology, BCIL, New Delhi
5. Regulatory Framework for GMOs in India (2006) Ministry of Environment and Forest, Government of India, New Delhi
6. Cartagena Protocol on Biosafety (2006) Ministry of Environment and Forest, Government of India, New Delhi

RBT076: AGRICULTURE BIOTECHNOLOGY **L T P**
3 1 0

UNIT I :Agriculture and Agricultural Biotechnology, Clonal Germplasm: Micro propagation, In vitro production of pathogen and contaminant free plants . (6)
UNIT II Biotechnology- Methods of Crop Improvement: Genetic Engineering of Crop Plants, Transgenic Plants, Molecular Markers, QTL Mapping. (6)

UNIT III : Microbes in Agriculture and Food: Applied Microbiology in the future of mankind, moving frontiers of applied microbiology, microbial enzymes and their applications in food processing and agrochemical industries, agro-waste utilization, biodegradable polymers and their applications, microbial polysaccharides; Production and utilization of essential amino-acids, chemicals from micro-algae. (12)

UNIT IV : Metabolite Production: Production of Secondary Metabolites, Production of foreign compounds in transgenic plant, Achievements and recent developments of genetic engineering in agriculture. (8)

UNIT V : Biofertilizers and Bioremediation: Microbial Biopesticides, Biofungicides, Herbicides, and Agricultural antibiotic Biotechnology in Agriculture: Ethical Aspects and Public Acceptance, Animal farming. (8)

Reference Books:
1. Biotechnology by B.D.Singh, Kalyani Publication
2. Biotechnology – Fundamentals and applications by S.S.Purohit, Student Edition
3. Agricultural Biotechnology-Arie Altman, CRCPress
4. Biotechnology- An Introduction by Susan R. Barnum, Vikas Publishing House

RBT077: Biomaterials L T P
3 1 0

Unit I: Introduction and overview of biomaterials Definition of biomaterials – biologically derived materials or materials compatible with biology. Biomaterials: Classification of bio-materials (based on tissue response), Tissue engineering, Biosensor. (8)

Unit II: Interactions of materials Interactions of materials with human body, bio-compatibility of materials, metals (stainless steels, cobalt-chromium alloys, titanium based alloys, nitinol), Ceramics (carmons, alumina, resorbable ceramics, surface reactive

ceremics), bio polymers(collagens, elastin, mucopolysachharides, cellulose and derivatives, chitin and other polysaccharides and composites as biomaterials. (8)

Unit III: Tissue Grafts and Soft Tissue applications Tissue graft and rejection process, skin grafts, connective tissue grafts, blood, fluid transfer implants, urological practise, microencapsulation of live animal cells, bulk space fillers, percutaneous devices. Materials for hard tissue replacement: orthopaedic implants, dental implants. (8)

Unit IV: Cardiovascular Implants and Ophthalmology Cardiovascular implants (blood clotting, blood rheology, blood vessels, heart, aorta and valves, lungs),cardiac pacemakers, Ophthalmology, materials for artificial organs transplant and extracorporeal device, Orthopaedic implants (joint replacement, knee joint replacement, temporary fixation devices) . (8)

Unit V: Legal Issues Recent developments in biomaterials, legal issues related to development of biomaterials. (8)

Text/Reference Books:

1) Biomaterials: An Introduction by Park J.B. and Lakes R.S., Plenum Press, New York.
2) Biomaterials, Medical Devices & Tissue Engineering: An Integrated Approach by Silver F.H., Chapman and Hall publication.
3) Biomaterials by Bhat Sujata V., Narosa PublishingHouse.
4) Biomaterials science: an introduction to materials in medicine by Buddy D. Ratner., Elsevier Academic Press.
5) Biomaterials: A Tantalus Experience by Jozef A. Helsen., Yannis Missirlis Springer.
6) Biomaterials by Temenoff Johnna S., Dorling Kindersley India Pvt Ltd.

RBT078: Applications of Natural Products **L T P**
3 1 0

Unit-I :Sources of crude drug: Biological, marine, Mineral and plant tissue culture as source of natural products. Various methods of extraction and isolation of phytopharmaceuticals namely infusion, decoction, maceration, percolation, hot continuous extraction, successive solvent extraction, supercritical fluid extraction, steam distillation, Counter-current Extraction, Ultrasound Extraction (Sonication). Parameters for selection of suitable extraction process. (8)

Unit-II: Phytochemical Screening: Screening of alkaloids, saponins, cardenolides and bufadienolides, flavonoids and leucoanthocyanidins, tannins and polyphenols, anthraquinones, cynogenetic glycosides, amino acids in plant extracts. Important therapeutic classes: antimicrobial, antidiabetics, hepatoprotectives, immmunomodulators, anti-cancer. (8)

Unit-III : Herbal cosmetics: Importance of herbals as shampoos (soapnut), conditioners and hair darkeners, (amla, henna, hibiscus, tea), skin care (aloe, turmeric, lemon peel, vetiver); Colouring and Flavouring agents from plants; Utilization of aromatic plants and derived products with special reference to sandalwood oil, mentha oil, lemon grass oil, vetiver oil, geranium oil and eucalyptus oil. (8)

Unit-IV : Nutraceuticals and Health Foods: Classification of Nutraceuticals, Health foods: Source, Chemical constituents, uses, actions and commercial preparations of, following health foods, Alfalfa, Bran, Angelica, Chamomile, Corn oil, Fenugreek, Ferverfew, Garlic, Ginseng, Ginkgo, Honey, Hops, Safflower oil, Soyabean Oil, Turmeric. Concept and examples of Adaptogens .(10)

Unit-V : Quality control of herbal drugs as per WHO, AYUSH and Pharmacopoeial guidelines-Extractive values, ash values. Determination of heavy metals, insecticides, pesticides and microbial load in herbal preparations. (6)

Text / Reference Books:

1. Manual K. Lindsey, Plant Tissue Culture, Springer U.K. Wagner.
2. Wagner and Bladt, Plant Drug analysis, Springer U.K.
3. A.R.Kashi, Industrial Pharmacognosy, Universities press
4. S.S.Agrawal, Herbal drug technology, Universities press
5. Quality Standards of Indian Medicinal Plants, Vol 10, (ICMR), New Delhi, 2012.
6. Indian Herbal Pharmacopoiea, K. M. Varghese Co.Bombay.
7. Craker L., Herbs, Spices And Medicinal Plants, CBS Publishers

8. N.R. Krishnaswamy Chemistry of Natural Products: A Unified Approach, University Press (India) Ltd., Orient Longman Limited, Hyderabad, 1999.

RBT751: Environmental Biotechnology Lab

L	T	P
0	0	2

1. Study of laboratory equipments used in Environmental Biotechnology lab.
2. To perform the waste Water Sampling by Random Sampling Method
3. Preparation of stocks solutions.
4. Estimation of Biological Oxygen Demand (BOD) of waste water.
5. Estimation of Chemical Oxygen Demand (COD) of waste water.
6. Estimation of Dissolved Oxygen
7. Estimation of Total Hardness in given Water Sample.
8. Estimation of Total dissolved and suspended solid in waste water
9. Alkalinity& Acidity of waste water
10. Estimation of optimum dosage of ferric chloride for removal of suspended matter
11. Nitrogen estimation by Kjeldahl method,
12. To determine the amount of total Coliform in the water sample

RBT752: Bioseperation & Down Stream Processing Lab

L	T	P
0	0	2

1. Characteristics of Bioproducts: Flocculation and conditioning of broth
2. Mechanical separation: Filtration and Centrifugation
3. Cell disruption
4. Membrane based seperation
5. Protein precipitation and its seperation: Aqueous two phase extraction, Ultra filtration and
Adsorption
6. Chromatography seperation based on size, charge, hydrophobic interaction

7. Gel analysis/ assay for dialysed product
8. Product crystallization and drying

DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY, LUCKNOW

Study and Evaluation Scheme
B.TECH. BIO-TECHNOLOGY
(Effective from the session: 2019-20)

4th Year, 8th Semester

S. No.	Subject Code	Subject Name	Teaching Deptt.	L-T-P	Th/Lab Marks	Sessional		Total	Credit
						Test	Assig. /Att.		
1		Open Elective Course-II	Other Department	3-0-0	70	20	10	100	3
2	RBT081-84	Departmental Elective-V	Core Department	3-1-0	70	20	10	100	4
3	RBT085-088	Departmental Elective-VI	Core Department	3-0-0	70	20	10	100	3
4	RBT851	Seminar	Core Department	0-0-3			100	100	2
5	RBT852	Project-II	Core Department	0-0-12	350		250	600	12
	Total							**1000**	**24**

Departmental Elective-V

RBT081: Experimental Biotechnology (NPTEL)
RBT082: Tissue Engineering (NPTEL)
RBT083: Introductory mathematical models for biologists (NPTEL)
RBT084: Database Design (NPTEL)

Departmental Elective-VI

RBT085: Biostatistics & design of experiments (NPTEL)
RBT086: Integrated waste management for smart cities (NPTEL)
RBT087: Industrial Biotechnology (NPTEL)
RBT088: Computer aided drug design (NPTEL)

Departmental Elective-V

RBT081: Experimental Biotechnology (NPTEL)

NPTEL Syllabus

Experimental Biotechnology - Web course

COURSE OUTLINE

Good lab practices and precautions, Spectroscopy: Recording UV/Visible absorption spectra for biomacromolecules and quantification; Fluorescence Spectroscopy: monitor equilibrium unfolding of a protein using tryptophan fluorescence; CD spectroscopy, IR spectroscopy. Chromatography: size exclusion chromatography of a crude mixture of proteins using standard matrix and dyes; HPLC, Fluorescence Microscopy: localization of antigen in cells; scanning and transmission electron microscopy. Atomic force microscope. Generation of polyclonal and monoclonal antibodies, Immuno-assays to detect and quantify antigens. Electrophoresis: electrophoresis of protein and nucleic acid. Characterization and quantification of proteins and nuceic acids. Molecular cloning techniques: Preparation and Transformation of competent cells, Small scale isolation of recombinant plasmid; Analysis of the recombinant plasmid using Restriction Endonucleases.

COURSE DETAIL

Module*	Topics and Contents	No of Lectures
1.Introduction	Introduction, Concept of buffers.	3
2. Spectroscopic experiments	Spectroscopic techniques: UV-Visible spectroscopy, Fluorescence spectroscopy, CD spectroscopy, IR spectroscopy. Protein estimation 1, 2, DNA estimation, unfolding, Protein unfolding, CD, IR	10
3. electrophoretic experiments	Electrophoresis; Principle, performing electrophoresis techniques, application of electrophoresis in analyzing macromolecules.	7
4. Chromatographic experiments	Chromatographic techniques; Principles, Column chromatography, HPLC	5
5. Immunological experiments	Antibody generation and purification, Immuno-assays to detect and quantify antigens.	4
6. microscopic experiments	Light Microscopy; Fluorescence microscopy, Atomic force microscope, Electron microscope, Scanning electron microscopy, Transmission Electron microsope.	7
7. Molecular cloning	Preparation and transformation of competent cells; Small scale isolation of recombinant plasmid, Analysis of the recombinant plasmid using Restriction Endonucleases.	4

*Mid course examination after module 3 and finals after the completion of module 6.

**Numbers of lectures are tentatively fixed.

NPTEL

http://nptel.ac.in

Biotechnology

Coordinators:

Dr. Nitin Chaudhary
Department of BiotechnologyIIT Guwahati

Dr. Vishal Trivedi
Department of BiotechnologyIIT Guwahati

References:

1. A. J. Ninfa and D. P. Ballou, *Fundamental Laboratory Approaches for Biochemistry and Biotechnology*, Wiley; 2nd Edition,1998.
2. J. Sambrook and D. W. Russell, *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, 3rd Edition, 2001.
3. Live Cell Imaging: A Laboratory Manual R. D. Goldman, J. R. Swedlow and D. L. Spector Cold Spring.Harbor Laboratory Press; 2nd edition, 2009
4. Basic Methods in Microscopy, Protocols and concepts from cells: A Laboratory Manual, D. L. Spector & R. D. Goldman (Editors.), Cold Spring Harbor Laboratory Press, 2006
5. A. Manz, N. Pamme and D. Iossifidis, Bioanalytical Chemistry, World Scientific Publishing Company, 2004
6. R.J. Simpson, Proteins and Proteomics: A Laboratory Manual, CSHL press, 2003

RBT082: Tissue Engineering (NPTEL)

NPTEL Syllabus

Tissue Engineering - Web course

COURSE OUTLINE

This course helps the learners to understand thoroughly the key concepts of tissue organization, remodeling and strategies for restoration of tissue function. This will enable them to design tissue regeneration and tissue injury repair strategies.

COURSE DETAIL

Sl. No	Course content	Duration (in hours)
1.	Introduction to tissue engineering, Cells as therapeutic Agents with examples, Cell numbers and growth rates.	2
2.	Tissue organization, Tissue Components, Tissue types, Functional subunits. Tissue Dynamics, Dynamic states of tissues, Homeostasis in highly prolific tissues and Tissue repair. Angiogenesis.	3
3.	Cellular fate processes, Cell differentiation, Cell migration - underlying biochemical process.	3
4.	Cell division - mitotic cell cycle, Cell death - biological description of apoptosis.	3
5.	Coordination of cellular fate processes - soluble signals, types of growth factors and chemokines, sending and receiving a signal, processing a signal, integrated responses, soluble growth factor receptors, Malfunctions in soluble signaling.	3
6.	Cell-extracellular matrix interactions - Binding to the ECM, Modifying the ECM, Malfunctions in ECM signaling. Direct Cell-Cell contact - Cell junctions in tissues, malfunctions in direct cell-cell contact signaling. Response to mechanical stimuli.	3
7.	Measurement of cell characteristics - cell morphology, cell number and viability, cell-fate processes, cell motility, cell function.	2
8.	Cell and tissue culture - types of tissue culture, media, culture environment and maintenance of cells in vitro, cryopreservation.	3

NPTEL

http://nptel.iitm.ac.in

Biotechnology

Pre-requisites:

- Basic Biology
- Cell Biology

Additional Reading:

- Articles in Journals: Biomaterials, Advanced Drug Delivery Reviews.

Hyperlinks:

- http://web.mit.edu/langerlab/
- http://faculty.virginia.edu/laurencinlab/index.htm

Coordinators:

Dr. S. Swaminathan
Centre for Nanotechnology & Advanced BiomaterialsSASTRA University

9.	Basis for Cell Separation, characterization of cell separation, methods of cell separation.	3
10.	Biomaterials in tissue engineering - biodegradable polymers and polymer scaffold processing.	3
11.	Growth factor delivery, Stem cells.	3
12.	Gene therapy.	1
13.	Bioreactors for Tissue Engineering.	1
14.	In vivo cell & tissue engineering case studies: Artificial skin, Artificial blood vessels.	3
15.	In vivo cell & tissue engineering case studies: Artificial pancreas, Artificial liver.	3
16.	In vivo cell & tissue engineering case studies: Regeneration of bone, muscle.	3
17.	In vivo cell & tissue engineering case studies: Nerve regeneration.	3
	Total	45

References:

- "Tissue Engineering", Bernhard O. Palsson, Sangeeta N. Bhatia, Pearson Prentice Hall Bioengineering.
- "Nanotechnology and Tissue engineering - The Scaffold", Cato T. Laurencin, Lakshmi S. Nair, CRC Press.

RBT083: Introductory mathematical models for biologists (NPTEL)

NPTEL SYLLABUS

NATIONAL PROGRAMME ON TECHNOLOGY ENCHANCED LEARNING

Mathematics for biologists

Biotechnology

Instructor Name: Prof.Ranjith Padinhateeri
Institute: IIT Bombay
Department: Biotechnology

About Instructor: I am a faculty in the department of biosciences and bioengineering at Iit Bombay. My research area is computational biophysics. I do theoretical study of biological systems using methods from physics.

Pre Requisites: :
Core/Elective: : Core
UG/PG: : Both
Industry Support :

Course Intro: : It is an introductory mathematics course for biology students with the aim of training them to do quantitative analysis of biological systems.

COURSE PLAN

SL.NO	Week	Module Name
1	1	Need of mathematics. FunctionsEquations as graphs and images (2D image & 3D objects)
2	2	Derivatives, meaning of derivatives, numerical computation of derivatives
3	3	Second derivative, maxima, minima, sketching functions
4	4	Integration with examples, numerical computation of integrals
5	5	Differential equations describing biological phenomena
6	6	Vectors with examples, differential equation with vector signs
7	7	Diffusion, Nernst equation, Einsteinâ€™s relation
8	8	Fourier seriesFourier transform: understanding scattering experiments
9	9	Basics of statistics, mean, standard deviation, distribution function
10	10	Binomial, Poisson and Normal distributions in biology
11	11	Survey, sampling, hypothesis testing z-test, t-test
12	12	Regression, curve fitting, Conclusion

RBT084: Database Design (NPTEL)

NPTEL Syllabus

Database Design - Video course

Module 1: Introductory Concepts (1 session)
Databases and Information Systems, An example usage context, Database system concepts and architecture.
Module 2: Semantic Database Design (3 sessions)
High-level conceptual modeling, ER Modeling concepts, ER Diagrams, Cardinality constraints, Higher-order relationships, Enhanced ER Model (EER), Weak-entity types, Subclasses and inheritance, Specialization and Generalization, Modeling of UNION types using categories
Module 3: Relational Model, Languages and Systems (7 sessions)
Relational algebra (2 sessions): Relational model concepts, Relational integrity constraints, Update operations on relations, Relational algebra model, ER to relational mapping
SQL (2 sessions): Data definition in SQL, Queries and update statements, Views, Integrity constraints, Specifying indexes, Embedded SQL.
IBM DB2 case study (2 sessions): Architecture of DB2, Data definition and manipulation in DB2.
EER to Relational mapping (1 session)
Module 4: Database design using the relational model (4 sessions)
Functional dependencies (2 sessions): Keys in a relational model, Concept of functional dependencies, Normal forms based on primary keys, Boyce-Codd Normal Forms

Further Dependencies (2 sessions): Multi-values dependencies and fourth normal form, Join dependencies and fifth normal form, Inclusion dependencies, Other dependencies and normal forms

Module 5: Storage and Indexing Structures (6 sessions)
Storage structures (3 sessions): Secondary storage devices, Buffering of blocks, File Organization, Heaps, Sorted Files, Hashing and overflow handling techniques, Dynamic hashing, Extensible hashing, Other file organizations
Indexing methods (3 sessions): Basic terminology, Primary indexes, Clustering index, Secondary index, Multilevel indexes, ISAM, B-trees, B+ trees, Inserting and searching algorithms for B+ trees, Other indexing methods

Module 6: Transaction Processing and Concurrency Control (6 sessions)
Transaction Fundamentals (3 sessions): OLTP environments, Concurrency issues, need for transactions, Necessary properties of transactions (ACID properties), Transaction states, serializability, Serial schedules, Conflict serializability, View serializability, Recoverable and non-recoverable schedules, Cascading rollbacks, Cascadeless schedules
Concurrency control (3 sessions): Serialized and non-serialized schedules, Testing for serializability, Locking, Lock compatibility matrix, Locking and serializability, Deadlocks and starvation, Two-phase locking (2PL) protocol, Conservative, strict and rigorous 2PL, 2PL with lock conversions, Timestamp-ordering based protocol, Multi-versioning protocol, Multi-granularity locking, Deadlock prevention protocols, Wait-die and wound-wait schemes, Time-out based schemes, Deadlock recovery, Nested transactions

NP-TEL

NPTEL

http://nptel.ac.in

Computer Science and Engineering

Coordinators:

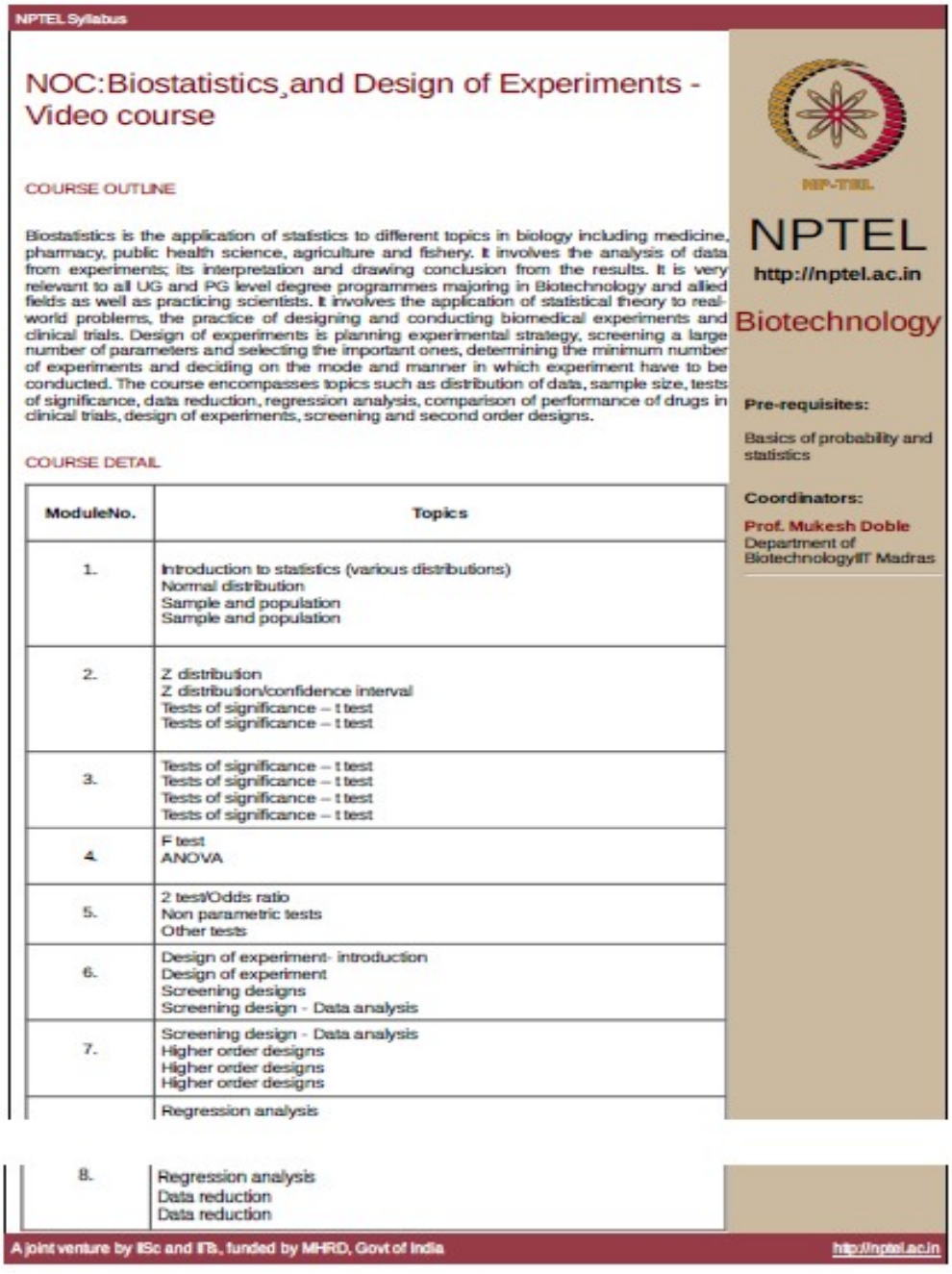
Dr. S. Srinath
IIT Bangalore

Prof. D. Janaki Ram
Department of Computer Science and EngineeringIIT Madras

Module 7: Database recovery techniques (3 sessions)
Recovery concepts, Deferred updates technique, Immediate update technique, Shadow paging, ARIES recovery algorithm
Module 8: Query Processing and Optimization (2 sessions)
Translating SQL into relational algebra, Basic query operations, Heuristics in query optimization, Selectivity and cost estimates in query optimization, Semantic query optimization
Module 9: Database Security and Authorization (1 session)
Discretionary access control, Mandatory access control and multi-level security, Statistical database security
Module 10: Enhanced Data Models for specific applications (2 sessions)
Active database concepts, Temporal databases, Spatial databases, multi-media
databases
Module 11: Distributed databases and issues (3 sessions)
Data fragmentation, replication and allocation in distributed databases, Types of distributed database systems Query processing in distributed databases, Concurrency control and recovery in distributed databases
Textbook:
Elmasri, Navathe. Fundamentals of Database Systems (Third Edition), Pearson Education, 2004.

Departmental Elective-VI

RBT085: Biostatistics & design of experiments (NPTEL)



NPTEL Syllabus

NOC:Biostatistics and Design of Experiments - Video course

COURSE OUTLINE

Biostatistics is the application of statistics to different topics in biology including medicine, pharmacy, public health science, agriculture and fishery. It involves the analysis of data from experiments; its interpretation and drawing conclusion from the results. It is very relevant to all UG and PG level degree programmes majoring in Biotechnology and allied fields as well as practicing scientists. It involves the application of statistical theory to real-world problems, the practice of designing and conducting biomedical experiments and clinical trials. Design of experiments is planning experimental strategy, screening a large number of parameters and selecting the important ones, determining the minimum number of experiments and deciding on the mode and manner in which experiment have to be conducted. The course encompasses topics such as distribution of data, sample size, tests of significance, data reduction, regression analysis, comparison of performance of drugs in clinical trials, design of experiments, screening and second order designs.

COURSE DETAIL

ModuleNo.	Topics
1.	Introduction to statistics (various distributions) Normal distribution Sample and population Sample and population
2.	Z distribution Z distribution/confidence interval Tests of significance – t test Tests of significance – t test
3.	Tests of significance – t test Tests of significance – t test Tests of significance – t test Tests of significance – t test
4.	F test ANOVA
5.	2 test/Odds ratio Non parametric tests Other tests
6.	Design of experiment- introduction Design of experiment Screening designs Screening design - Data analysis
7.	Screening design - Data analysis Higher order designs Higher order designs Higher order designs
8.	Regression analysis Data reduction Data reduction

NPTEL
http://nptel.ac.in
Biotechnology

Pre-requisites:

Basics of probability and statistics

Coordinators:

Prof. Mukesh Doble
Department of Biotechnology IIT Madras

A joint venture by IISc and IITs, funded by MHRD, Govt of India
http://nptel.ac.in

RBT086: Integrated waste management for smart cities (NPTEL)

INTEGRATED WASTE MANAGEMENT FOR A SMART CITY

PROF. BRAJESH KUMAR DUBEY
Department of Civil Engineering
IIT Kharagpur

TYPE OF COURSE : Rerun | Core | UG/PG
COURSE DURATION : 12 weeks (29 Jul'19 - 18 Oct'19)
EXAM DATE : 17 Nov 2019

INTENDED AUDIENCE : B.E/B.Tech, M.E/M.Tech, M.S, B.Sc, M.Sc, PhD, Field Professionals and Academicians
PRE-REQUISITES : Environmental Sciences, Introduction to Environmental Engineering
INDUSTRIES APPLICABLE TO : Larsen and Tourbo, Tata Group of Industries, Ramky Group of Industries, IF&LS Environment

COURSE OUTLINE :

This course has emphasises on Integrated Solid Waste Management aspects within the broad subject area of Integrated Waste Management for a Smart City. The issues of Municipal Solid Waste (MSW) management, Construction and Demolition (C&D) Waste and Electronic Waste Management will be covered in this course. The topics will include: generation rates and waste composition; integrated waste management issues, collection, recovery, reuse, recycling, energy-from-waste, and landfilling; Biological treatment of the organic waste fraction - direct land application, composting, and anaerobic digestion. The environmental impact of waste management and its relationship on the big picture sustainable development and smart city development will be discussed. A major focus of this course will be the role of MSW management within the various initiatives of the Govt. of India including: Swachh Bharat Mission, Smart Cities as well as Make in India. The challenges of waste management for smart cities will also be discussed taking case studies from the first list of 20 smart cities identified in the first phase for this program. This will be followed by overview of the Construction and Demolition (C&D) Waste and Electronic Waste (E-Waste) management issues in India in general and for the smart cities in particular. The new rules with respect of C&D Waste and E-Waste Management will be covered. The challenges of managing these waste streams effectively will be discussed.

ABOUT INSTRUCTOR :

Dr.Brajesh Kumar Dubey is an Associate Professor in the Division of Environmental Engineering and Management at Indian Institute of Technology (IIT), Kharagpur, India. Dr. Dubey has more than a decade of research, teaching, training and industrial outreach experience in the areas of Integrated Solid and Hazardous Waste Management, Life Cycle Assessment (LCA) and Sustainable Engineering. He has collaborated with UN agencies, World Bank, National Science foundation, Ontario Ministry of Environment and Auckland Regional Council on various projects including that in the area of LCA.

COURSE PLAN :

Week 01 : Introduction to Solid Waste Management
Week 02 : Municipal Solid Waste Characteristics and Quantities
Week 03 : MSW Rules 2016, Swachh Bharat Mission and Smart Cities Program
Week 04 : Municipal Solid Waste Collection, Transportation, Segregation and Processing
Week 05 : Disposal of Municipal Solid Waste
Week 06 : Biochemical Processes and Composting
Week 07 : Energy Recovery from Municipal Solid Waste
Week 08 : Current Issues in Solid Waste Management and Review of MSW Management Status in First List of 20 Smart Cities in the Country
Week 09 : Construction and Demolition (C&D) Waste Management - Overview
Week 10 : C&D Waste – Regulation, Beneficial Reuse of C&D Waste Materials
Week 11 : Electronic Waste (E-Waste) Management – Issues and Status in India and Globally
Week 12 : E-Waste Management Rules 2016 and Management Challenges

RBT087: Industrial Biotechnology (NPTEL)

INDUSTRIAL BIOTECHNOLOGY

PROF. DEBABRATA DAS
Department of Biotechnology
IIT Kharagpur

TYPE OF COURSE : Rerun | Elective | UG
COURSE DURATION : 12 weeks (29 Jul'19 - 18 Oct'19)
EXAM DATE : 16 Nov 2019

INTENDED AUDIENCE : B.E/B.Tech, M.E/M.Tech
PRE-REQUISITES : Knowledge in microbiology, Biochemistry and mathematics in 10+2 level
INDUSTRIES APPLICABLE TO : DuPont India, IFB Agro Industry, IOC; ONGC, Dr. Reddy's Laboratories, Biocon United beverages.

COURSE OUTLINE :

The course aims to provide fundamental insights to exploit enzymes and microbes for the manufacturing of products which have a huge industrial significance. It uniquely blends the science and engineering with various biochemical processes to obtain products of diverse fields such as chemicals, food, bioenergy etc. The course introduces bioreactors, its types, operation methods and provides an experimental demonstration of the same. Strategies to obtain higher yields, design of the reactors and production of biofuels from microbes are thoroughly explained. Students of various disciplines such as biotechnology, chemical engineering, food engineering, and pharmaceutical industries can be benefitted from the course as it discusses the existing bioprocess applications such as wine and cheese making, antibiotics and vaccines etc. The course majorly focusses on the applications and allows students to gain practical knowledge rather than mere theory. Major bottlenecks for the operation of biochemical industries will be discussed.

ABOUT INSTRUCTOR :

Dr. Debabrata Das pursued his doctoral studies from Indian Institute of Technology (IIT) Delhi. He is a Senior Professor at IIT Kharagpur. He was also associated as MNRE Renewable Energy Chair Professor. He has pioneered the promising R&D of Bioenergy production processes by applying fermentation technology. Prof. Das is involved in three different area of research: Gaseous energy recovery from organic wastes; algal biorefinery and CO_2 sequestration; and microbial fuel cell. He is presently involved in teaching both undergraduate and post-graduate courses on Biochemical Reaction Engineering; Aspects of Biochemical Engineering; Bioprocess Plant and Equipment Design; and Bioprocess Technology for the students of Department of Biotechnology; Department of Chemical Engineering; Department of Chemistry and School Energy Science and Engineering.

COURSE PLAN :

Week 01 : Introduction, Microbes and enzymes of industrial importance
Week 02 : Different types of bioreactors and bioreactor design
Week 03 : Microbial growth, substrate degradation and product formation kinetics, Tutorial 1
Week 04 : Instrumentation, Sterilization of air, media and reactor
Week 05 : Upstream and Downstream processing
Week 06 : Production of Oxychemicals I
Week 07 : Production of Oxychemicals II
Week 08 : Production of Oxychemicals III
Week 09 : High fructose corn syrup, Cheese making, and Single cell production
Week 10 : Vaccines production and Metal leaching
Week 11 : Bioenergy- Gaseous fuels: Biohydrogen, Biomethane and Microbial fuel cell; Liquid fuels: Bioethanol, Biodiesel and Biobutanol
Week 12 : Aerobic and Anaerobic wastewater treatment processes

RBT088: Computer aided drug design (NPTEL)

COMPUTER AIDED DRUG DESIGN

PROF. MUKESH DOBLE
Department of Biotechnology & Bioengineering
IIT Madras

TYPE OF COURSE : Rerun | Core | UG/PG
COURSE DURATION : 8 weeks (29 Jul'19 - 20 Sep'19)
EXAM DATE : 29 Sep 2019

INTENDED AUDIENCE : B.E/B.Tech, M.E/M.Tech
PRE-REQUISITES : Prior knowledge of biochemistry, bioinformaticsl
INDUSTRIES APPLICABLE TO : Pharmaceutical industries/Biopharma/biotech

COURSE OUTLINE :

Drug discovery and development is a time consuming and expensive process., taking about 10 years and costing about US 1.0 B dollars. Several candidates that enter clinical trials fail because of several reasons. Computer assisted drug design can speed up the process, reduce surprises and predict the properties, thereby reduce the cost of R&D. The course will cover structure and target based design, molecular modeling, quantum mechanics, drug likeness properties, QSAR and pharmacokinetic and dynamics using several softwares that are freely available.

ABOUT INSTRUCTOR :

Prof. Mukesh Doble is a Professor at the Department of Biotechnology at IIT Madras. He Has previously worked in Imperial chemical Industries (ICI) and General Electric (GE) for 20 years. Areas of research are Biomaterials, Biopolymers, and Drug design. He has Published 280 papers and 10 books and filed 10 patents (including two US). He has delivered online video courses in Downstream processes, Medical Biomaterials and Biostatistics and Design of Experiments

COURSE PLAN :

Week 01 : Introduction to drug discovery
Week 02 : Structure and property
Week 03 : ADME-rules
Week 04 : Force field/MM/QM
Week 05 : Boundary conditions/Conformation
Week 06 : QSAR/Pharmacophore
Week 07 : Enzymes/proteins structures/docking
Week 08 : PK/PD