SCHEME OF EXAMINATION
&
SYLLABUS

for

Master of Technology (Biotechnology)
2019 onwards

UNIVERSITY SCHOOL OF BIOTECHNOLOGY
GGS INDRAPRASTHA UNIVERSITY
Sector 16C, Dwarka, New Delhi - 110 078

**Approved in the Academic Council Sub-committee meeting on 03-07-2019.*

Master of Technology (Biotechnology)
Scheme and Syllabus, 2019

Semester 1

Serial no.	Course type	Course code	Course name	L	T	P	Credits	T/P	M/D	C/E	(U/NU) ES
1	Core 1	**BT- 501**	Genomics	3	0	0	3	T	D	C	U
2	Core 2	**BT-503**	Proteomics	3	0	0	3	T	D	C	U
3	Program Specific Elective 1	**(Select any one)**		3	0	0	3	T	D	E	U
		BT- 505	Pharmaceutical Biotechnology								
		BT-507	Pharmacoinformatics					T	D	E	U
		BT-509	Nutraceuticals & Functional Foods					T	D	E	U
4	Program Specific Elective 2	**(Select any one)**		3	0	0	3	T	D	E	U
		BT-511	Biochemical Engineering								
		BT-513	Agriculture Biotechnology					T	D	E	U
		BT-515	Food Process Engineering and Quality Control					T	D	E	U
5	Lab 1	**BT-551**	Advanced Biotechnology Lab-1	0	0	4	2	P	D	C	U
6	Lab 2	**BT-553**	Advanced Biotechnology Lab-2	0	0	4	2	P	D	C	U
7	RM & IPR	**BT-517**	Research Methodology and IPR	2	0	0	2	T	D	C	U
8	Audit Course 1		As per the list below	2	0	0	0	T	D	E	NU
9	Open Elective 1		As per the list below	4	0	0	4	T	D	E	U
			Total	**20**	**0**	**8**	**22**				

Audit course 1 [Select any one]:

S. No.	Course Code	Course Name
1	**BT-527**	English for Research Paper Writing
2	**BT-529**	Disaster Management
3	**BT-533**	Value Education
4	**BT-535**	Vedic Science &Traditional Knowledge

Open Elective 1 [Select any one]:

S. No.	Course Code	Course Name
1	**MS-101**	Management Process and Organisational Behaviour (USMS)
2	**GEN-101**	Research Methods and Legal Writing (USLLS)
3	**IPR-107**	Nature, Emergence and Development of IPR (USLLS)
4	**BT-519**	Industrial Biotechnology (USBT)
5	**BT-521**	Industrial Safety (USBT)
6	**EM -609**	Energy Resource and Technology (USEM)

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Semester 2

Serial no.	Course type	Course code	Course name	L	T	P	Credits	T/P	M/D	C/E	(U/NU) ES
1	Core 3	**BT- 502**	Epigenomics	3	0	0	3	T	D	C	U
2	Core 4	**BT-504**	Biotechnology in Healthcare	3	0	0	3	T	D	C	U
3	Program Specific Elective 3	**(Select any one)**		3	0	0	3	T	D	E	U
		BT-506	Clinical Immunology &Immunotechnology								
		BT-508	Advanced Animal Biotechnology					T	D	E	U
		BT-510	Biophysics and Structural Biology					T	D	E	U
4	Program Specific Elective 4	**(Select any one)**		3	0	0	3	T	D	E	U
		BT-512	Virology								
		BT-514	Advanced Plant Biotechnology					T	D	E	U
		BT-516	Molecular and Cellular Biology of Cancer					T	D	E	U
5	Lab 3	**BT-552**	Advanced Biotechnology Lab-3	0	0	4	2	P	D	C	U
6	Lab 4	**BT-554**	Advanced Biotechnology Lab-4	0	0	4	2	P	D	C	U
7	Mini Project	**BT-556**	Mini Project	0	0	4	2	P	M	C	U
8	Audit Course 2		As per the list below	2	0	0	0	T	D	C	NU
9	Open Elective 2		As per the list below	4	0	0	4	T	D	E	U
			Total	**18**	**0**	**12**	**22**				

Audit course 2[Select any one]:

S. No.	Course Code	Course Name
1	**BT-536**	Constitution of India
2	**BT-538**	Pedagogy Studies
4	**BT-542**	Personality Development through Life Enlightenment Skills

Open Elective 2 [Select any one]:

S. No.	Course Code	Course Name
1	**IPR-102**	Law of Patents (USLLS)
2	**MS-102**	Management of Technology, Innovation and Change (USMS)
3	**IPR-106**	Law of Designs, Layout Designs andGeographical Indications (USLLS)
4	**EM-602**	Air Pollution , Meteorology and Control (USEM)
5	**BT-526**	Biotic and Abiotic Stress Biology
6	**BT-528**	Biosafety, Bioethics and IPR (USBT)
7	**BT-530**	Advanced Downstream Processing (USBT)
8	**BT-532**	Bioprocess Modelling & Control (USBT)
9	**BT-534**	Statistical Methods in Engineering & Technology (USBT)

Semester 3

Serial no.	Course type	Course code	Course name	L	T	P	Credits	T/P	M/D	C/E	(U/NU) ES
1	Program Specific Elective 5	(Select any one)		3	0	0	3	T	D	E	U
		BT-601	Biomanufacturing Principles and Practices								
		BT-603	Systems and Synthetic Biology					T	D	E	U
		BT-605	Bioproduct Development and Bioentrepreneurship					T	D	E	U
2	Open Elective 3		As per the list below	4	0	0	4	T	D	E	U
3	Dissertation Phase 1	BT-651	Dissertation Phase 1	0	0	20	10	P	M	C	U
			Total	**7**	**0**	**20**	**17**				

Open Elective 3 [Select any one]:

S. No.	Course Code	Course Name
1	**BT-607**	Bioinformatics (USBT)
2	**BT-609**	Waste to Energy(USBT)
3	**BT-611**	Biodiversity and Biotechnology (USBT)
4	**EM-701**	EIA & Risk Analysis (USEM)

Semester 4

Serial no.	Course type	Course code	Course name	L	T	P	Credits	T/P	M/D	C/E	(U/NU)ES
1	Dissertation Phase 2	**BT-652**	Dissertation Phase 2	0	0	32	16	P	M	C	U
			Total	**0**	**0**	**32**	**16**				

Note:

1) **The programme of study shall be governed by ordinance 11 of the University.**

2) **Total credits for M.Tech. = 77 credits**
Minimum credits required = 70 credits

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The University School of Biotechnology has developed the standard academic format incorporating the current recommendations of national agencies for PG programmes in Engineering and Technology. The scheme describes the number of credits, weightage for lectures, laboratory work and projects in accordance with the regulatory/statutory authorities.

The introduction of Mini Project (BT-556) is aimed to ensure preparedness of students to undertake dissertation. The evaluation of Mini Project will be done by submission of project report at the end of 2nd semester and shall be evaluated by external examiner for 60 marks [external / end semester examination] and by the internal examiner for 40 marks [internal / continuous evaluation throughout the semester]. The internal examiner would be the supervisor under whose guidance the Mini Project is submitted.

The dissertation work of one year duration [phase I (BT-557) and Phase II (BT 558) combined] has been given strong weightage in the curriculum. The evaluation of Phase I (BT 557) will be done at the end of 3rd semester through oral presentation/viva voce and submission of midterm progress report. This shall be evaluated by external examiner for 60 marks [external / end semester examination] and by the internal examiner for 40 marks [internal / continuous evaluation throughout the semester]. The internal examiner would be the supervisor under whose guidance the dissertation is done. Each student shall be allotted a supervisor in the beginning of 3 rd semester for Phase I and phase II, under whose guidance the dissertation will be carried out and project/progress report is to be submitted.

The evaluation of phase II (BT-558) will be done at the end of 4th semester through oral presentation/viva-voce and submission of final report. This shall be evaluated for 60 marks [external / end semester examination] by external examiner and for 40 marks [internal / continuous evaluation throughout the semester] by the internal examiner. The internal examiner would be the supervisor under whose guidance the dissertation is submitted.

The introduction of **Audit 1** and **Audit 2 courses** covering subjects of developing desired attitude among the learners is on the line of initiatives such as Unnat Bharat Abhiyan, Value Education, Disaster Management, Pedagogy, Constitution of India, Personality Development, Indian Culture etc. The evaluation of 100 marks (NUES) would be by the internal examiner. The internal examiner would be the subject teacher taking the course for the students for the respective semester.

The courses included under **open electives** are based on choice based credit system (CBCS) and are aimed to special skill developments. These courses are desired to develop interdisciplinary approach for biotechnology students by introducing courses offered by other University School of Studies.

Out of 77 credits, one has to earn at least 70 credits to qualify M.Tech. Degree, however student is required to appear in all the courses.

Paper code	Paper title	Credits	Hours
BT-501	GENOMICS	3	30

Course objectives:

This course on Genomics has been designed to introduce students to the structural and functional aspects of genomes across organisms. It also aims to familiarize them with the developments in the experimental approaches used by researchers to understand the complexity and diversity of genomes. Recent advances in genomics have transformed the way in which biologists study cells and biological systems. Furthermore, there is an enormous potential for the future widespread use of genomics in various areas including medicine, pharmacology and agriculture, with implications in prediction, prevention, diagnosis and treatment of human diseases, as well as conservation and sustainable development. This would require qualified and trained manpower that can effectively use the knowledge of genomics for the benefit of humans.

Course outcomes:

1. Students will be able to appreciate nuances of epigenetic gene regulatory mechanisms.
2. Course will provide in-depth understanding of chromatin structure and function.
3. Course will develop inclination for research in the field of epigenetics.

Unit 1: Genome Architecture, Sequencing and Annotation

Structure and Organization of prokaryotic and eukaryotic genomes; Organellar genomes; Genome sizes-C-value paradox; Concept of Metagenome, Synthetic genome and Microbiome; Classical approaches to sequencing DNA; Automated sequencing; Genome sequencing approaches-Hierarchical and Shotgun approaches; Genome assembly; Next Generation Sequencing Technologies; Annotation of genome.

Unit 2: Model Organisms andComparative Genomics

Definition and characteristics of model organisms; Advantages and shortcomings of using model organisms in research; Characteristic features of genomes of model organisms-yeast, *C. elegans*, *D. melanogaster*, Zebrafish, Mice, *Arabidopsis* and Rice; Synteny; Human Genome Project- Historical background; Goals of human genome project; Salient features of the human genome; ENCODE project, Hapmap project, Ethical, Social and Legal implications.

Unit 3: Genome Variation

Types of genome variation; Techniques to study variation; Connection to disease, agriculture and evolution; Genetic testing; Pharmacogenomics; Toxicogenomics.

Unit 4: Functional Genomics

Forward genetics; Reverse genetics; Analysis of single gene expression-Northern blot, RNAse protection assays; RT-PCR, Real-time PCR; Whole genome expression analysis techniques- Subtractive hybridization, DD-PCR, RAP-PCR, Microarray technology, SAGE and RNA-Seq; Genetic interaction screens; Genome-wide mutant libraries; Gene-knockouts; RNA interference screens; Chemical genetics; Genome editing-CRISPR and other genome editing tools.

Unit 5: Molecular Interactions

Pull-down assays; Immunoprecipitation; ChIP; ChIP on chip; Phage-display; TAP-tagging; Yeast two hybrid assay and its variations.

Books/References:

1. Systems Genetics Ed.- F. Markowetz and M. Boutros (2015) Cambridge University Press.
2. Bioinformatics and Functional Genomics 3rd Edition (2015) by J. Pevsner, Wiley-Blackwell.
3. An Introduction to Genomics 2nd Edition (2012) by A. M. Lesk, Oxford University Press.
4. Genomics and Bioinformatics: An Introduction to Programming Tools for Life Sciences 1st Edition (2012) by T. Samuelsson, Cambridge University Press.
5. From Genes to Genomes: Concepts and Applications of DNA Technology, 3rd Edition (2011) by J.W. Dale, M.v. Schantz and N. Plant, Wiley-Blackwell.
6. A Primer of Genome Science 3rd Edition (2009) by G. Gibson and S. V. Muse, Sinauer Associates, Inc.
7. Principles of Genome Analysis and Genomics, 3rd Edition (2003) by S.B. Primrose and R. Twyman, Blackwell publishing.
8. Functional Genomics, Edited by S. Hunt and F. Livesey (2000), Oxford University Press.

Paper code	Paper title	Credits	Hours
BT-503	**PROTEOMICS**	3	30

Objectives:

To study the entire range of proteins present in any cell/tissue/organism under specific conditions.
To obtain a global view of cellular processes at the protein level.

Course outcomes:

This course provides knowledge of the use of high throughput techniques to study the entire range of proteins present in any cell/tissue/organism under specific conditions, to obtain a global view of cellular processes at the protein level. Its various aspects include protein diversity, abundance, structure, function and regulation, including post-translational modifications and interactions with other biomolecules and the various associated techniques from a functional genomics perspective. This knowledge should help the students to absorb and retain the related practical skills better when the opportunity arises in academia/industry.

Unit 1: Introduction:

Protein structure and function, evolution of proteomics from protein chemistry, the proteome and the genome, functional protein families, need for proteomics, scope and challenges of proteomics, systems biology in proteomics.

Unit 2: Abundance-based Proteomics:

Sample preparation for proteomics, challenges associated with low- and high-abundant protein, gel-based proteomics (2-DE, DIGE, BN-PAGE), modifications in gel electrophoresis techniques, merits and demerits of gel-based proteomics, gel-free proteomics [two dimensional and multidimensional liquid chromatography including MudPIT, isotope based techniques like Isotope-Coded Protein Label (ICPL), COmbined FRActional DIagonal Chromatography (COFRADIC)], applications, merits and demerits of gel-free proteomics, detection of proteins in polyacrylamide gels and on electroblot membranes (Organic dyes and silver stains, reverse stains, colloidal dispersion stains, organic fluorophore stains, metal chelate stains, electroblotting).

Unit 3: Quantitative and Functional Proteomics:

Stable isotope labeling by amino acids in cell culture (SILAC), isotope coded affinity tag (ICAT), isobaric tagging for relative and absolute quantitation (iTRAQ), SELDI, immunoprecipitation (IP),different types of protein chips, detection and quantification of proteins bound to protein chips, emerging protein chips technologies, mass spectrometry in proteomics: overview, protein identification using MS data, protein identification using MS/MS data, mass spectrometry applications, mass spectrometry data analysis, search engines for MS protein identification.

Unit 4: Structural Proteomics and Protein-Protein Interaction:

Application, merits and demerits of structural proteomics, Yeast-2-hybrid, co-immunoprecipitation (Co-IP), pull-down assays, tandem affinity purification (TAP).

Unit 5: Protein Modifications in Proteomics:

Introduction, phosphoproteins; glycoproteins, ubiquitin etc., challenges in PTMs, techniques for characterization of PTMs, recent advances in proteomics.

Books /References:

1. Principles of Proteomics by R. M. Twyman. Second edition, BIOS Scientific Publishers (2013).
2. Introduction to Proteomics by Daniel C. Liebler. Humana Press Inc. (2002)
3. Proteome analysis interpreting the genome. Edited by David W. Speicher. Elsevier (2004)
4. Proteomics: From Protein Sequence to Function. S.R. Pennington and M.J. Dunn. Viva Books (2002).

Paper code	Paper title	Credits	Hours
BT-505	PHARMACEUTICAL BIOTECHNOLOGY	3	30

Course objectives:

1. *Identify appropriate sources of drugs/medical information*
2. *Apply theoretical bases and practical applications of core pharmaceutical biotechnology subjects in concerned Industries and organizations. Use the latest techniques for the search of new products from natural sources.*
3. *Understand and analyze novel techniques of production, purification and characterization of enzymes, biotechnologically produced biomedicines and pharmaceuticals.*
4. *Develop skills in biotechnological techniques for obtaining and improving the quality of natural products. The course imparts knowledge in Pharmaceutical Biotechnology so that the student is competent to work in pharmaceutical companies and R & D organizations to develop cost effective yet safe and quality biomedicines and pharmaceuticals.*

Course outcomes:

1. *A postgraduate student should acquire detailed Knowledge and understanding of pharmaceutical biotechnology with special emphasis on industrial aspects. So that He/she has to maintain a high standard of professional ethics when get employed in industry. He/she should continuously upgrade the acquired knowledge by keeping in touch with contemporary research through national and international journals elated to pharmaceutical biotechnology.*

Unit 1: Pharmaceuticals, Biologicals and Biopharmaceuticals

An overview Pharmaceutical& Biopharmaceutical biotechnology, current status & future prospects. Pharmaceuticalsof animal origin, plant origin, and of microbial origin, pharmacogenetics and pharmacogenomics.

Unit 2: The Drug Development Process

Drug discovery, rational drug design. Delivery ofbiopharmaceuticals, Pre-clinical trials, and clinical trials. Drug metabolism, pharmacokinetic and pharmacodynamics , Absorption, distribution, metabolism, elimination of drugs

Unit 3: Drug Manufacturing Process

International pharmacopoeia. Guide to goodmanufacturing practice. Manufacturing facility. Sources of pharmaceuticals, productionof final product and analysis of final product. Production and formulation of Biotech Compounds, Post production handling and delivery:

Unit 4: Pharmaceutical Biotechnology Broduct in Clinical use

Hematopoietic Growth Factors, Interferons and Interleukins, Insulin, Growth Hormones, Recombinant Coagulation Factors and Thrombolytic Agents, Monoclonal Antibodies, Follicle-Stimulating Hormone .

Unit5: Regulatory Issues and Drug Product Approval for Biopharmaceuticals

Books/ References:

1. Biopharmaceuticals and industrial prospective. Gray Walsh & B. Murphy, *Kluwer publishers* (2004).
2. Biopharmaceuticals. Gray Walsh, *Wiley John & Sons, Inc.* (2003).
3. The practice of Medicinal chemistry. Camille G. Wermuth, Academic Press, (2003).
4. Pharmaceutical Biotechnology: Concepts and Applications 1st Edition. by Gary Walsh , Publisher: Wiley;1edition (, 2007)
5. Pharmaceutical Biotechnology:Fundamentals and Applications.Editors: Crommelin, Daan J. A., Sindelar, Robert D., Meibohm, Bernd (Eds.).2013 Springer-Verlag New York
6. Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications Hardcover – April 12, 2004.by Oliver Kayser (Editor), Rainer H. Müller (Editor).Wiley-Blackwell; 1 edition (April 12, 2004)
7. Handbook of Pharmaceutical Biotechnology 1st Edition. by Shayne Cox Gad (Editor)Wiley-Interscience; 1 edition (June 11, 2007)

Paper code	Paper title	Credits	Hours
BT-507	PHARMACOINFORMATICS	3	30

Course objectives:

1. *To be able to know the popular computational databases for pharmaceutical molecules and allied information for pharmaceutical analysis*
2. *To be able to understand the computer-based methods for pharmaceutical analysis*
3. *To have an idea of basic acts, schedules and regulations in Pharma and allied industry*

Course outcomes:

1. *The student is expected to independently analyze the potential of an bioactive molecule through computational approach.*
2. *The student is expected to be able to classify independently the type and class of formulation as per national acts and regulations.*

Unit 1: Introduction to Pharmacoinformatics

Importance of informatics in drug design and development, Applications of pharmacoinformatics, limitations of in silico approaches, Chemical structure representations, structure viewers and structure drawing tools, chemical structure file formats, importance of different formats and their inter-conversions, compatibility.

Unit 2: Databases

Chemical databases and their uses, PubChem, Zinc, ChEMBL, ChemDB, Drug Bank, Chemspider, eMolecules, Comparative Toxicogenomics Database (CTD), Structural Database (CSD), ligand Expo, etc.
Protein-ligand complexes databases and their uses, Protein DataBank (PDB), Binding MOAD (Mother Of All Database), Ligand Protein DataBase (LPDB), AffinDB, Protein Ligand Database (PLD), BindingDB, SCORPIO, Psychoactive Drug Screening Program (PDSP), etc.
Ligand complexes sets for testing programs: BAPPL complexes set, DNA Drug complex dataset, Binding Database, Kuntz Protein Test Set, etc.

Unit 3: Ligand Design

GANDI, SPROUT, BREED, LigBuilder, MOE, etc. Lead optimization, e-LEA3D, 3DLigandSite, PASS, etc. Ligand screening, Corina, PharmaGist,CATS, LigPrep, etc

Unit 4: Molecular Modelling

Homology modeling, *in silico* ADMET, PK/DB, Leadscope toxicity database, qADME, qTOX, pre ADME, Molcodetoolbox, OSIRIS Property Explorer, etc. QSAR, OpenMolGRID, Molconn-Z, MolInfo, E-Dragon, Lazar, etc.

Unit 5: Biosafety and Ethics in Pharma Industry

Drugs and cosmetics Act, 1940 and Rules 1945, overview of schedules with references to Schedule B, C& C1, D, E1, F & F1, F2, F3, FF, G, H, J, K, M, N, P, R, V, W, X, Natural products, AYUSH , Nutraceuticals, Brief study of Prescription and Non Prescription.

Books / Reference s:

1. Malone, P.M., Kier, K.L., Srtanovich, J.E. Drug Information-A Guide for Pharmacists. McGraw-Hill, 2006.
2. Krishnan Namboori P K and Deepak O M. Computational Drug Design and Delivery systems principles and applications, Springer. 2012.
3. Prasad V. Bharatam, Modeling and Informatics in Drug Design, John Wiley & Sons Inc.2007.
4 Tagelsir Mohamed Gasmelseid, Pharmacoinformatics and Drug Discovery Technologies: Theories and Applications, IGI-Global, 2012

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Paper code	Paper title	Credits	Hours
BT-509	NUTRACEUTICALS AND FUNCTIONAL FOODS	3	30

Course objectives:

1. *To understand various nutraceuticals and functional foods, their types, mechanisms of action, clinical testing and toxicity aspects.*
2. *To understand the role of biotechnology in their production*
3. *To know the national and international regulatory framework and growth potential in the world market.*

Course outcomes:

1. *To be able to appreciate the role of food as medicine.*
2. *To differentiate between an active pharmaceutical ingredient and an functional biomolecule.*

Unit 1: Biotechnology of Plant-based Functional Foods

Biofortification with essential micronutrients, phytochemicals, modification of macronutrients; production of hypoallergenic foods; reduction of antinutrients. Biotechnology of animal-based functional foods: meat products, dairy foods etc.

Unit 2: Pro-biotics and Pre-biotics

Health benefits, Efficacy & Safety. Designers food, specialty foods,
substitutes (eg. Milk replacers, low sodium slat, sugarless sweet meats, food for sports, geriatric).
Nutraceuticals with reference to Indian Context and Ayurveda.

Unit 3: Processing Technologies

Processing technologies to retain bio-active components (artificial drying, drug drying, spray drying, freeze drying, vacuum drying, micro-wave vacuum drying, membrane separation in processing bioactive components (pre-concentration, fractionation, hybrid process, new membrane processes), non-thermal methods, minimally processed ingredients.

Unit 4: Packaging Technologies for Functional Foods

Fruits & vegetables (processed plant products, fresh plantproducts), probiotics (yogurt, dried cultures), intermediate moisture products, oils and fats. choice ofpackaging materials. active packaging. Microencapsulation and nano emulsion technology for delivery ofnutraceuticals and functional foods.

Unit 5: Biosafety and Ethics in Pharma Industry

Natural products, AYUSH , Nutraceuticals, Brief study of Prescription and Non Prescription. . Future strategies for the development of biotechnology- enhanced functional foods and their contribution to human nutrition. US-FDA and FASSI regulatory aspects.

Books / References:

1. Advances in food research by G.F.Stewart, 1966
2. Functional foods: Designer foods, pharma foods and nutraceuticals by Goldberg, 1994
3. Advances in food and nutrition research by Steve L. Taylor, 2007
4. Functional food Ingredients &Nutraceuticals by John Shi, Taylor & Francis 2007
5. Biotechnology in functional foods & nutraceuticals by DebasisBagchi, Francis C. Lau and Dilip K. Ghosh, CRC Press, Boca Raton, 2010.

Paper code	Paper title	Credits	Hours
BT-511	BIOCHEMICAL ENGINEERING	3	30

Course objectives:

To introduce the students to the abiotic phase interactions in a biological system from an engineering point of view. This would primarily deal with developing a basic understanding of transport phenomena, with emphasis on heat and mass transfer. These are critical for modeling and scale up of biological processes, since they link the micro environment of the cell with the measurable macro environment. In addition, enzyme engineering is included, with a focus on its applied aspects. A prior exposure of the student to fundamentals of biochemical engineering is desirable, though not essential. However, a background in mathematics such as calculus is essential.

Course outcomes:

At the end of the course, the student should be able to construct an abiotic phase model of various biological systems like fermentation modeling and ancillary processes. The student should also be able to design enzyme-catalyzed reactors and do scale-up. This course is complementary to the bioprocess modelling course, which deals with biotic phase modeling.

Unit 1: Principles of Physical Transfer Process

Heat conduction and molecular diffusion, Fluid flow and momentum transfer, Laminar vs. Turbulent flow, Transfer phenomena in turbulent flow, Film coefficients of heat and mass transfer and their estimation.

Unit 2: Transport Phenomena in Bioprocess Systems

Gas-liquid mass transfer in cellular systems, Basis mass-transfer concepts, Rates of metabolic oxygen utilization , Determination of oxygen transfer rates, Measurement of k_la using gas-liquid reactions, Mass transfer for freely rising or falling bodies , Mass-transfer coefficients for bubbles and bubbles swarms , Estimation of dispersed phase interfacial area and holdup and correlations, Forced convection mass transfer, General concepts and key dimensionless groups, Correlations for mass-transfer coefficients and interfacial area related to sauter mean (d_{sm}) bubble or droplet diameter, Overall k_la estimates and power requirements for sparged and agitated vessels, Mass transfer across free surfaces, Other factors affecting k_la, 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 correlations, Heat transfer, Heat transfer correlations , Overall coefficients and film coefficients, Forced flow of fluids in tubes and tube banks, Liquids in jacketed or coiled vessels.

Unit 3: The Kinetics of Enzyme-Catalyzed Reactions

The enzyme-substrate complex and enzyme action, Simple kinetics with one and two substrates, Michaelis-menten kinetics, Evaluation of parameters in the Michaelis-menten equation, Kinetics for reversible reactions, two-substrate reactions, and cofactor activation, Determination of elementary-step rate constants, Relaxation kinetics, Investigation of transient-kinetics, Patterns of substrate concentration dependence , Substrate activation and inhibition, Multiple substrates reacting on a single enzyme, Modulation and regulation of enzymatic activity, The mechanisms of reversible enzymatic activity, Analysis of reversible modulator effects on enzyme kinetics, Other influences on enzyme activity, The effect of pH on enzyme kinetics in solution, Enzyme reaction rates and temperature, Enzyme deactivation, Mechanisms and manifestations of protein denaturation, Deactivation models and kinetics, Mechanical forces acting on enzymes, Strategies for enzyme stabilization, Enzyme reactions in heterogeneous systems.

Unit 4: Applied Enzyme Catalysis

Applications of hydrolytic enzymes, Hydrolysis of starch and cellulose, Proteolytic enzymes, Esterase applications, Enzyme mixtures, pectic enzymes etc., Other applications of enzymes in solution, Medical applications of enzymes, Nonhydrolytic enzymes in industrial technology, Immobilized-enzyme technology, Enzyme immobilization, Industrial processes.

Unit 5: Immobilized Enzyme Kinetics, Enzyme reactor Design, Analysis of Data

Effects of external mass-transfer resistance, Analysis of intraparticle diffusion and reaction and estimation of parameters, Simultaneous film and intraparticle mass-transfer resistances, Effects of inhibitors, temperature, and ph on immobilized enzyme catalytic activity and deactivation ,scale up principles

Books/References:

1. Biochemical Engineering Fundamentals. By J.E. Bailey, D.F. Ollis, 2nd Ed. 1986, Mc.Graw Hill
2. Biochemical Engineering : An Introductory Textbook by Debabrata Das &Debayan Das, Jenny Stanford Publilshing, 2019 ISBN: 978-981-4800-43-3.
3. Biochemical Engineering. By S. Katoh, J Horiuchi, F. Yoshida, 2nd Ed., 2015, Wiley-VCH

Paper code	Paper title	Credits	Hours
BT-513	AGRICULTURE BIOTECHNOLOGY	3	30

Course objectives:

1. *To gain knowledge about recent advancement in agricultural biotechnology.*
2. *To understand the mechanisms responsible for plant disease/stress resistance/tolerance.*
3. *To study various research approaches for crop improvements.*
4. *To study heterologous/homologous plant products*

Course outcomes:

1. *Understanding of plant responses to various stresses at physiological, biochemical and molecular level.*
2. *Understanding of plant stress tolerance mechanisms*
3. *Genetic engineering approaches for crop improvements will be understood.*
4. *Factors involved in host/plant interaction will be understood.*

Unit 1: Molecular Breeding

Concept and methodology of different types of molecular markers. Role of molecular markers in crop and farm animal improvement, conservation of biodiversity; marker assisted selection; QTL mapping.

Unit 2:

Molecular and biochemical basis of plant disease resistance, signaling pathways, protein kinases, virus induced gene silencing. Molecular basis of plant resistance to various abiotic stresses like drought, salinity, heavy metals, high temperature etc.

Unit 3: Genetic Engineering of Plants

Production of transgenic plants for fungal, bacterial and viral disease resistance; herbicide resistance, drought and other abiotic stress resistance; quality parameters: Modification of nitrogen fixing capabilities; gene pyramiding

Unit 4: Choloroplast Genetic Engineering

Methodology, applications in herbicide resistance, production of biopharmaceuticals, edible vaccines, foreign gene expression, Limitations.

Unit 5: Molecular Farming

Use of plants and animals for production of neutraceuticals, edible vaccines and other desired products, Plant Microbe interaction: Host-pathogen interaction, host-symbiont interaction, host-Agrobacterium interaction.

Books/ References:

1. Agricultural Biotechnology by Arie Altman. Marcel Dekker, Inc. (2001).

2. Plants, Genes and Crop Biotechnology (2003) 2nd Edition by Chrispeels, M.J. &Sadava D.E. American Society of Plant Biologists, Jones and Bartlett Publishers, USA.

3. Biochemistry and Molecular Biology of Plants: Edited by Buchanan B.B., Gruissem W, and Jones RL (2000), American Society of Plant Biologists, USA.

4. Various research and review journals like Nature Biotechnology, Current Opinion, Trends and Annual Reviews.

Paper code	Paper title	Credits	Hours
BT-515	FOOD PROCESS ENGINEERING AND QUALITY CONTROL	3	30

Course objectives:

1. To understand various processing technologies to protect and preserve food.
2. To understand the role of biotechnology in their production processes.
3. To know the national and international regulatory framework and growth potential in the world market.

Course outcomes:

1. *To be able to appreciate the role of machinery in processed food.*
2. *To be able to differentiate between a process to increase shelf-life and process which decreases the nutritional value.*

Unit 1: Process Time Calculations

Sterilizers and accessories used in canning industries; Engineering aspects of pasteurizer; homogenizer, evaporators (basic principle and single-effect evaporator) and concentrators used in food industries; Seaming machine.

Unit 2: Construction of Cold Storage

Different types of freezers including plate contact freezer, air blast freezer, cryogenic freezing and refrigerated vans, : Heat exchangers (including paraflow HEs); Extruders – Basic principles and types, Difference between single- and twin-screw extruders; Kneader; Oil expeller.

Unit 3: Various Types of Driers (Basic Principle and Drying Time)

Tray drier, roller drier, spray drier, fluidized bed drier, freeze drier and solar drier.

Unit 4: Quality Control and Quality Assurance

GHP, GMP, QMS, HACCP, FSMS and other quality standards, TQM in food and bioproducts.

Unit 5:

Industrial safety and ethics in food processing industry, Future strategies for the development of biotechnology- enhanced functional foods and their processing , product developemnt. US-FDA and FASSI regulatory aspects.

Books / Reference:

1. The Fundamentals of Food Engineering; Charm SE; 1963, AVI Pub.
2. Bakery Technology & Engineering; Matz SA; 1960, AVI Pub.
3. Dictionary of Food Science & Technology, Blackwell Publishing
4. Engineering Properties of Foods; Rao MA & Rizvi SSH; 1986, Marcel Dekker Inc.
5. Fundamentals of Food Process Engineering; Toledo RT; 2nd ed, 2000, CBS Publishers.
6. Food process engineering, D.R.Heldman and R.P.Singh

Paper code	Paper title	Credits	Hours
BT-517	RESEARCH METHODOLOGY AND IPR	2	20

Course objectives:

1. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
2. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
3. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Course outcomes:

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics

Unit 1:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2:

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Unit 3: Nature of Intellectual Property

Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 4: Patent Rights

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 5: New Developments in IPR

Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and Indian Institues.

Books / References:

1.Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.
6. Niebel, "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Propertyin New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Paper code	Paper title	Credits	Hours/week
BT-527	ENGLISH FOR RESEARCH PAPER WRITING	NIL	2

Course objectives:

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title
Ensure the good quality of paper at very first-time submission.

Course outcomes:

1. To be able to write scientific literatures as per the global standards

Unit1:

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Unit 2:

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Unit 3:

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Unit 4:

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

Unit 5:

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions, useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Suggested Readings:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

Paper code	Paper title	Credits	Hours/week
BT-529	DISASTER MANAGEMENT	NIL	2

Course objectives: *Students will be able to:*

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction andhumanitarian response.

2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

3. develop an understanding of standards of humanitarian response and practical relevance inspecific types of disasters and conflict situations.

4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

Course outcomes:

1. To be able to identify and follow proper procedure during a disaster.

2. To be able to organise management strategies during a disaster and post disaster procedures to cope with the situation.

Unit 1: Introduction

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference,Nature, Types And Magnitude.

Unit 2: Repercussions of Disasters and Hazards:

Economic Damage, Loss Of Human And Animal life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

Unit 3:Disaster Prone Areas in India

Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

Unit 4:Disaster Preparedness and Management

Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Unit 5: Risk Assessment

Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

Unit 6: Disaster Mitigation

Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company.

2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi.

3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

Paper code	Paper title	Credits	Hours/week
BT-533	VALUE EDUCATION	NIL	2

Course objectives:

1. *Understand value of education and self- development*
2. *Imbibe good values in students*
3. *Let the should know about the importance of character*

Course outcomes:

1.Knowledge of self-development
2.Learn the importance of Human values
3.Developing the overall personality

Unit 1: Values and Self-development

Social values and individualattitudes. Work ethics, Indian vision of humanism., Moral and non-moral valuation. Standards and principles, Value judgements, Importance of cultivation of values.

Unit 2: Sense of Duty. Devotion, Self-reliance. Confidence,Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity.Patriotism.Love for nature ,Discipline,

Unit 3: Personality and Behaviour Development

Soul and Scientificattitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.

Unit 4: Universal Brotherhoodand Religious Tolerance

True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

Unit 5: Character and Competence

Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence ,Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively

Suggested Readings:

1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

Paper code	Paper title	Credits	Hours/week
BT-535	VEDIC SCIENCE AND TRADITIONAL KNOWLEDGE	NIL	2

Course objectives:

1. *To get the essence of Indian traditional knowledge in different fields of life.*
2. *To be able to appreciate the vedic scriptures and thier current day relevance.*
3. *To encourage the interest in vedic literatures.*

Course outcomes:

1. *To be able to apply the ancient Indian traditional knowledge in day to day life.*
2. *To be able to link the science of the vedis era to the current day knowledge.*

Unit 1:

Introduction to the Vedas, Vedangas, Upanisads, Brahmanas, Aranyakas. Astronomy, Astrology, Cosmology, Cosmogony, Space time, The cosmic order, mathematics, chemistry, metallurgy , physics.

Unit 2:

Metereology, seismology, botany and vedic flora, zoology, Medicine and vedic healing. Agriculture management, geology, Environmental science and ecology.

Unit 3:

Common disease conditions and thier traditional healing: Acne, Common cold, Common fever, Depression, Diarrhoea, Common cough, Fatigue, Obesity, Stress.

Unit 4:

Indian traditional knowledge of natural treatment for diseases, Case studies on urban diseases Asthma, Arthritis , Cervical spondylosis, diabetes, Blood pressure, blood cholesterol.

Unit 5:

Mantras and their use, Asanas and their importance, Susrutasamhita, Charakasamhita, the modern science and its lineage to traditional knowledge.

Suggested Readings:

1. Research materials and web resources.

2. The vedic scriptures

3. Ancient Indian literature

Management Process & Organizational Behaviour

Course Code: MS 101

L - 4, Credits - 4

Objective: This course is designed to expose the students to fundamental concepts of management, its processes and behavioral dynamics in organizations.

Course Contents

Unit I

Introduction to Management: Meaning and Nature of Management, Evolution of Management, Managerial Functions, Skills, Tasks and Responsibilities of a Professional Manager, Management by Objectives, Case Study.

Unit II **(12 Hours)**

Process of Management: Planning-Process and Techniques, Directing-Principles and Process, Controlling-Process and Techniques, Decision Making Models, Case Study.

Unit III **(14 Hours)**

Fundamentals of Organizational Behaviour: Introduction and Meaning, OB Models & Approaches, Work Force Diversity, Organizational Justice, Whistle Blowing and Social Responsibility, OB Trends, Case Study.

Individual Processes and Behaviour: Personality, Perception, Attitude, Learning, Motivation, Managing Emotions and Stress at Work.

(14 Hours)

Unit IV

Interpersonal Processes and Behavior: Communication, Work teams and group dynamics, Leadership, Conflict Management, Interpersonal Behavior and Relations, Transactional Analysis, Case Study.

Organizational Processes and Structure: Organizational Design and Structure, Organizational Culture and Climate, Organizational Change and Development, Cross Cultural Organizational Behavior.

(16 Hours)

Text Books

1. Robbins, Judge S.P., T.A., Vohra, N. (2016). Organizational Behaviour, 16 e. Pearson Education.
2. Nahavandi, A., Denhardt R. B., Denhardt, J. V., Aristigueta M. P. (2015). Organizational Behaviour, Sage Publications.

Reference Books

1. Nelson D.L., Quick, J.C. & Khandelwal, P. (2014). ORGB, 2 e. Cengage Learning.
2. Greenberg, J. and Baron, R.A. (2015). Behaviour in Organization, 10 e. Pearson Education.
3. Newstrom, J.W. & Davis, K., Organizational Behaviour Human Behavior at Work, 12 e. Mc GrawHill Education.
4. George, J. M. & Jones, G.R. (2009). Understanding and Managing Organizational Behaviour 5 e. Pearson Education.

Master of Technology (Biotechnology)
Scheme and Syllabus, 2019

Paper code	Paper title	Credits	Hours
GEN-101	RESEARCH METHODS AND LEGAL WRITING	4	40

Course objectives:

This paper will make students understand research methodology and different components of legal research and their application. The paper will attempt to instill rational tools of analysis in the students so that their research contributes to the development of socio- legal dimensions.

Course outcomes:

Unit1: Precepts

a. Nature, Scope and Objectives of Legal Research andMethodology
b. Methods of Legal Research
c. CollaborativeResearch
d. Doctrinal andNon-Doctrinal

Unit 2:ResearchDesigns

a. Identification and Formulation of ResearchProblem
b. Hypothesis and Research Design (Characteristics andcontents)
c. Database for Legal Research: Legislations, Judicial Decisions, JuristicWritings and Traditional and OnlineDatabases

Unit 3:ResearchTechniques

a. Methodology: Tool and Techniques for collection of data, collection of case materials and juristic literature, use of historical and comparative research material and use of questionnaire andinterview.
b. Census and Survey
c. Sampling: Types, Merits andDemerits
d. Observation
e. Interview,Questionnaire

Unit 4: Data ProcessingReportWriting

a. Data Analysis andInterpretation
b. Report Writing
c. Supervision
d. Guidelines forresearchers
e. ResearchEthics

Text Books:

1. S.K. Verma and M. Afzal Wani (Eds.) *Legal Research and Methodology,* Indian Law Institute (2001) 2nd Edition.
2. Goode and Hatt, "*Methods in Social Research*", Singapore, Mc. Graw Hill Book Co., 1985(reprint).

References:

1. Baxi, Upendra, „*Socio-Legal Research in India – A Program Schriff*, ICSSR, Occasional Monograph, 1975.
2. Cohen, Morris L., „*Legal Research*", Minnesota, West Publishing Co.1985.
3. Ghosh,B.N.,„*ScientificMethodandSocialResearch*",NewDelhi,SterlingPublishers Pvt. Ltd.,1984.
4. Johari J.C. (ed), „*Introduction to the Method of Social Sciences*", New Delhi, Sterling Publishers Pvt. Ltd.1988.
5. Kothari C.K., „*Research Methodology: Method and Techniques*", New Delhi, Wiley Eastern Ltd., 1980.
6. Stone, Julius, „*Legal System and Lawyer's Reasoning*", Sydney, Maitland Publications, 1968.

Paper code	Paper title	Credits	Hours
IPR- 107	NATURE, EMERGENCE AND DEVELOPMENT OF IPR	4	40

UNIT – I: Introduction to Intellectual Property

a. Concept & Meaning of Intellectual Property
b. Nature and Characteristics of Intellectual Property
c. Origin and Development of Intellectual Property
d. Kinds of Intellectual Property

UNIT –II: Theories of Intellectual Property

a. Justification and Rationale for Protecting Intellectual Property
b. Balancing the Protection of IPR and Public Policy Objective
c. Theories of IPR:-
   i. Natural Theory
   ii. Hegelian Philosophy (Personality Theory)
   iii. Lockes' Theory of Property (Labour Theory)
   iv. Social Contract Theory
   v. Social Planning Theory
   vi. Incentive Theory
   vii. Reward Theory
   viii. Prospect Theory
   ix. Schumpeterian Theory
   x. Economic Theory

UNIT – III: International Institutions and Basic International Conventions

a. Paris Convention for the Protection of Industrial property, 1883
b. The Berne Convention, 1886
c. TRIPS Agreement, 1994
d. International Institutions Concerned with Intellectual Property

UNIT – IV: Contemporary Issues in IPR

a. Interface between IPR and Human Rights
b. Interface between IPR and Competition Law
c. IPR and sustainable development
d. The Impact of Internet on IPR
e. IPR Issues in Biotechnology
f. E-Commerce and IPR issues

Text Books:

1. David I. Bainbridge, *Intellectual Property*, Longman, 9th Edition, 2012
2. Peter Groves, *Sourcebook on Intellectual Property Law*, Routledge-Cavendish, 1997.

References:

1. Susan K Sell, Private Power, *Public Law: The Globalization of Intellectual Property Rights*, Cambridge University Press, 2003
2. N.S. Gopalakrishnan & T.G. Ajitha, *Principles of Intellectual Property*, Eastern Book Company,2nd Edition , 2014
3. Jayashree Watal, *Intellectual Property Rights in the WTO and Developing Countries*, Oxford University Press, 2001
4. Lionel Bently& Brad Sherman, *Intellectual Property Law,* Oxford University Press, 3rd Edition, 2008
5. Peter Drahos, *A Philosophy of Intellectual Property*, Dartmouth Pub Co, 1996
6. Duggal Pavan, *Legal Framework on Electronic Commerce & Intellectual Property Rights*, Universal Publishing House, 2014
7. Paul Torremans, *Intellectual Property And Human Rights*, Kluwer Law International, 2008
8. Steven D Anderman, *Interface Between Intellectual Property Rights and Competition Policy*, Cambridge University Press, 2007.
9. Philippe Cullet, *Intellectual Property Protection and Sustainable Development*, Lexis Nexis, 2005

Paper code	Paper title	Credits	Hours
BT-519	INDUSTRIAL BIOTECHNOLOGY	4	40

Course objectives:

1. To understand the industrial applications of biotechnology and bio-processing.
2. To understand the production process parameters , to calculate and analyze them.

Course outcomes:

1. To be able to calculate the process parameters in order to optimize a process.
2. To be able to maintain a processing at its maximum potential with optimum cost and biological safety.

Unit1: Air Sterilization

Airborne microbes, methods of air sterilization, types of air filters, selection criteria for Air filters, Medium sterilization: Filtration, thermal destruction, Continuous sterilization, Design of continuous sterilizer.

Unit 2: Transport Phenomena of Bioprocesses

Fluid mechanics in bioprocesses, boundary layer theory, incompressible fluid flow inside pipe, Mass transfer in bioprocess, Oxygen diffusion in fermentation broth, determination of oxygen absorption rate, Heat transfer in bioprocess, Power consumption.

Unit 3: Enzymatic Reaction Kinetics

Bioreactor modelling for enzymatic reactions, inhibition kinetics, factors affecting enzyme reactions, immobilized enzymes - merits and demerits, Characterization of immobilized enzymes, Kinetics of immobilized enzymes.

Unit 4: Industrial Fermentation Processes

Bakers' yeast fermentation process, Ethanol fermentation process, Citric acid fermentation process, case study on other fermentative products and processes.

Unit 5: Applications of Industrial Biotechnology

In agricultural bioprocesses, single cell proteins, biopharmaceuticals, food and dairy, bioremediation, biofuels, biosensors.

Books / References:

1. Biochemical Engineering : An Introductory Textbook by Debabrata Das &Debayan Das, Jenny Stanford Publilshing, 2019 ISBN: 978-981-4800-43-3.
2. Biochemical Engineering Fundamentals. by J.E. Bailey and D.F. Ollis, 2nd Ed. 1986, Mc.Graw Hill
3. Principles of Fermentation Technology (3rd Edn.) by Peter Stanbury, Allan Whitaker and Stephen Hall, Butterworth-Heinemann (Elsevier), 2016 ISBN: 9780080999531
4. Bioprocess Engineering: Basic Concepts (2ndEdn.) by Michael L. Shuler and FikretKargi, Pearson publishing , ISBN: 978-0131228573

Paper code	Paper title	Credits	Hours
BT-521	INDUSTRIAL SAFETY	4	40

Course objectives:

1. *To understand the importance of safety in a processing area.*
2. *To understand the wear and tear in production and the fault tracing.*
3. *To know how to maintain industrial safety in a processing area.*

Course outcomes:

1. To be able to draft a safety manual for different processes and tools.
2. To be able to maintain a processing equipment to its full usable life with maximum safety.

Unit 1: Industrial Safety

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit 2: Fundamentals of Maintenance Engineering

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit 3: Wear and Corrosion and Their Prevention

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit 4: Fault Tracing

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Unit 5: Periodic and Preventive Maintenance

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Books / References:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

Paper code	Paper title	Credits	Hours
EM-609	ENERGY RESOURCES AND TECHNOLOGY	L: 4 T/P: 0 Credits: 4	

UNIT 1:Energy Fundamentals
Different forms of energy, Non-renewable and renewable energy resources, Concept of work and power; conductive, convective and radiant heat transfer, standard cycles, Energy UNITs.
Energy and Development: World energy scenario, Energy use in different sectors- Indian scenario, Energy and development issues, environmental implications, Need for new and alternate energy resources; Urban and rural energy use systems and patterns.

UNIT 2:Conventional Energy Sources and Technology
Resources and reserves ofCoal , petroleum , natural gas and lignite. Coal gasification and liquefaction, fluidized bed system and combined cycle system; Cracking of petroleum, petroleum products. Nuclear energy : Fission energy, fusion energy, Nuclear power generation- Fission reactors, Breeder reactors, Fusion technology, Nuclear energy issues. Magnetohydrodynamic power, principle of MHD generator, MHD equation.

UNIT 3:Renewable Energy Sources
Basic principles and harnessing of different alternate energy resources -Solar energy , Flat plate collectors, photovoltaic cells , Solar power; Wind energy, wind farms ; Geo-thermal energy ; Hydropower and micro-hydel power ;Tidal energy; Ocean Thermal Energy Conversion(OTEC) Technology; Hydrogen as alternate fuel.Biomass energy, Energy plantations, Bioconversion technologies, biomass gasification for thermal, electrical and mechanical power generation, biomass gasifier systems, gasifier coupled dual fuel engine system, improved biomass cooking stoves.

UNIT 4: Energy Conservation and Energy Economics :
Principles of energy conservation, Energy efficiency at national level, improving energy efficiency, energy analysis, concept of exergy, (theoretical treatment), economic development and the environment, capital recovery factor, levelized annual cost, economic analysis of wind electric generation and thermal power systems.

Text/References:

1. Edward H. Thorndike (1976), Energy & Environment: A Primer for Scientists and Engineers, Addition-Wesley Publishing Company, Reading.
2. Rakos Das Begamudre (2000), Energy Conversion Systems, New Age International Publishers, New Delhi.
3. C. S. Solanki (2009), Renewable Energy Technologies-A Practical Guide for Beginners, PHI Learning Pvt. Ltd., New Delhi
4. David Merrick and Richard Marshall(1981). Energy-Present and Future options, John Wiley & Sons, New York.
5. Y P Abhi and Shashank Jain (2006). Handbook on Energy audit and Environment Management, TERI, New Delhi
6. D. D. Mishra (2012) Energy, Environment, Ecology and Society, S. Chand & Company Ltd. New Delhi.

w.e.f. academic session 2019-2020

Paper code	Paper title	Credits	Hours
BT-502	**EPIGENOMICS**	3	30

Course objectives:

This course has been designed to introduce fundamentals of epigenetic gene regulation to M. Tech. (Biotechnology) students. The curriculum will provide an in-depth look into the genomic landscape and chromatin with specific emphasis on covalent modifications that regulate its existence in different forms in cell/tissue-specific/developmental stage-specific manner. A holistic view of the different epigenetic pathways converging to silence and activate genes during plant and animal development will be taught by a combination of lectures, discussions and introduction to recent reviews on these topics.

Course outcomes:

1. Students will be able to appreciate nuances of epigenetic gene regulatory mechanisms.
2. Course will provide in-depth understanding of chromatin structure and function.
3.Course will develop inclination for research in the field of epigenetics.

Unit 1:

Introduction to histones and histone variants, chromatin packing, transcription factors and gene expression; Non-coding RNAs.

Unit 2:

DNA methylation, Histone modifications, Epigenetic regulators: Eukaryotic cytosine DNA methyltransferases (C5), histone methyltransferases, Histone Acetylases (HAT) and deacetylases (HDAC), Chromatin remodeling factors.

Unit 3:

Polycomb group complexes in plants and animals, gene silencing mechanisms, RNA-directed DNA methylation: Polymerase IV and Polymerase V complexes, heterochromatin formation; RNA interference (RNAi).

Unit 4:

Regulation of chromatin structure and gene regulation by DNA and histone methyltransferases, methyl DNA binding proteins, TE silencing and its role in genome stability, Genomic Imprinting in Plants and Mammals – Mechanism, Dosage compensation; Epigenetic reprogramming and X-chromosome inactivation.

Unit 5:

Epigenetic regulation of plant developmental processes: flowering time, developmental switches, stress response; position effect variegation, paramutation; DNA demethylation.

Unit 6:

Methodologies for methylome profiling: Methylation sensitive-insensitive restriction enzymes, Microarray based and Next generation sequencing based methods

Unit 7:

Epigenetics and disease: Rett syndrome, ICF syndrome, Cancer; Introduction to Epigenome based therapeutics (

Book / References:

1. Epigenetics, Second edition (2015) Ed. C. David Allis. Cold Spring Harbor laboratory Press
2. From Genes to Genomes: Concepts and Applications of DNA Technology, 3rd Edition (2011) by J.W. Dale, M.v. Schantz and N. Plant, Wiley-Blackwell
3. The Biology of Plants (Cold Spring Harbor Symposia on Quantitative Biology LXXVII) (2013). Edited by Terri Grodzicker, Rob Martienssen, David Stewart and Bruce Stillman. Cold Spring Harbor laboratory Press.
4. Genome Science: A Practical and Conceptual Introduction to Molecular Genetic Analysis in Eukaryotes (2014). Cold Spring Harbor Laboratory Press.
5. Genetics and Genomics in Medicine 1st Edition (2014) by T. Strachan, J. Goodship, P. Chinnery, Garland Press.

Code	Paper title	Credits	Hours
BT-504	BIOTECHNOLOGY IN HEALTH CARE	3	30

Course objectives:

This course will enable students to acquire knowledge on the fundamentals of healthcare biotechnology. It enables them to understand emerging and advanced concept in molecular pathogenesis of disease and role of biotechnology in diagnosis, prevention and therapeutics. This programme will facilitate the students to acquire knowledge in fields various aspects and molecular tools used in clinical application in alleviation of human disease. It will also empower the students to have advanced focus on the molecular basis of diseases and development of advanced therapeutics.

Course outcomes:

A postgraduate student should acquire detailed Knowledge and understanding the role of Biotechnology in Healthcare. He/she should continuously upgrade the acquired knowledge by keeping in touch with contemporary research through national and international journals elated to Healthcare Biotechnology.

Unit1: Introduction

Molecular basis of disease, Biotechnology in disease prevention, therapeutics and diagnosis, Personalized Medicine Therapeutic Biomolecules.

Unit2: Molecular Diagnostics

Gene based diagnosis, tools for screening of infectious disease, genetic disease, Monoclonal Antibodies

Unit3: Therapeutics

Radiological Agents, Cardiovascular Drugs and endocrine drugs,
Chemotherapeutic Agents, Oligonucleotides and OligosaccridesGene therapy, Antisense therapy, Ribozyme

Unit 4: Vaccines

Cancer immunotherapy, Polysaccharide bacterial vaccines, approaches to carbohydrate based, cancer Monoclonal Antibodies

Unit5: Drug Delivery and Targeting:

Basic concepts and novel advances, Brain-specific drug
targeting strategies, Pulmonary drug delivery, Cell specific drug delivery

Books / References:

1. Pharmaceutical Chemistry by Christine M. Bladon. *John Wiley & Sons, Ltd.*(2002).
2. Burger's Medicinal Chemistry and Drug Discovery (5th edition) by Manfred E. Wolff. A *Wiley & Sons, Inc.* (2000).
3. Drug Targeting Organ-Specific Strategies by Grietje Molema and Dirk K. F. Meijer. Wiley-*VCH.* (2002).
4. Medical Biotechnology, 1e Paperback – 5 Dec 2008, by JuditPongracz BSc PhD DrHabil (Author), Mary Keen BSc PhD (Author),Publisher: Churchill Livingstone; 1 edition (5 December 2008)
5. Healthcare Biotechnology: A Practical Guide 1st Edition by Dimitris Dogramatzis,: 689 pages,Publisher: CRC Press; 1 edition (December 14, 2010)
6. Biotechnology in Healthcare: An Introduction to Biopharmaceuticals

Paper code	Paper title	Credits	Hours
BT-506	CLINICAL IMMUNOLOGY AND IMMUNOTECHNOLOGY	3	30

Course objectives:

To provide students with an overview of the basic concepts and the principles of immune system.
2. To understand impact of different receptors cell signalling pathways in immune response.
3. To learn about the latest technologies used in detection of diseases.
4. To gain insight into the immune response to various infectious and non-infectious diseases.
5. To acquaint the students with recent technologies being employed for production of antibodies used in therapy and diagnosis.

Course outcomes:

At the end of the course, the student will be able to:
1. Understand the hallmarks of immune system
2. Analyse the results of immunological assays
3. Well versed with the advances made in the field of immunology

Unit 1:Fundamental Concepts and Anatomy of the Immune System

Components of innate and acquired immunity; complement; organs and cells of the immune system: structure and function of antigens and antibodies; antigen processing and presentation; major histocompatibility complex, immunological basis of self–non-self- discrimination and immunological memory.

Unit 2: Receptors and Cell Signalling

Immunoglobulin superfamily; B-cell receptor; T-cell receptor; cytokines, chemokines and their receptors; signal transduction pathways; B and T cell activation

Unit 3: Principles and Applications of Laboratory Tests in Immunology

Principles of antigen-antibody interactions;; antibody assays - precipitation, agglutination, immunoelectrophoresis and complement mediated immune reactions; advanced immunological techniques - RIA, ELISA, Western blotting, immunofluorescence, immunoelectron microscopy, flow cytometry and ELISPOT assay; total and differential counts in human peripheral cells,; CMI techniques- lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, HLA typing

Unit 4: Techniques for Generation of Antibodies

Production of polyclonal and monoclonal antibodies, hybridoma technology, Genetic engineering techniques to make human antibodies- chimeric antibodies & humanized antibodies, therapeutic and diagnostic antibodies.

Unit 5: Vaccinology

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein- based vaccines; Peptide vaccines; conjugate vaccines

Unit 6: Clinical Immunology-

Immunity to Infection: Bacteria, viral, protozoan infections (one example from each group); Hypersensitivity – Type I-IV; Types of autoimmune diseases and their treatment; Transplantation and immunosuppressive therapy; Tumor immunology –Immune response to tumors and tumor evasion of the immune system.

Books/References:

1. Kuby Immunology By Owen, Punt, &Stranford, 7th, Seventh Edition, 2013, Macmillan press.
2. The Elements of Immunology by FahimHalim Khan, Pearson Education, 2009.
3. Essentials of Immunology: Ivan Riot- Blakswell Scientific Publications, Oxford, 6th Edition.
4. Infection and immunity by John Playfair and Gregory Bancroft, 3rd edition, Oxford Univ.press. 2008.
5. Monoclonal antibodies: Principles and practice by J.W. Goding. 3rd edition, Academic Press.

Paper code	Paper title	Credits	Hours
BT-508	ADVANCED ANIMAL BIOTECHNOLOGY	3	30

Course Objectives:

1. To provide students with an understanding of the basic concepts and the principles of animal cell culture.

2. To learn about various techniques used in animal biotechnology and understand their impact on human welfare

Course Outcomes:

At the end of the course, the students will gain an insight into the concepts and techniques of animal biotechnology and its industrial and medical applications.

Unit 1:

Biology of cultured cells, growth characteristics, cell adhesion, proliferation, differentiation, Energy metabolism, contact inhibition, anchorage dependence; cell-cell communication.

Unit 2:

Equipments and Materials for animal cell culture, Introduction to balanced salt solutions, media components and its preparation, Defined and serum free media and their advantages and disadvantages.

Unit 3:

Types of cell culture (primary and secondary culture) development and routine maintenance of cell lines, authentication and validation,Cloning and selection, cell synchronization and cell manipulation, cell sorting, measurement of cell viability and cytotoxicity. Propagation of stem cells, culture of tumor cells, Introduction to cell culture reactors and scale-up (in suspension and in monolayer) and automation.

Unit 4:

Tools, techniques and applications; Multicellular spheroids (3D tissue culture model for cancer research), Introduction to concepts of tissue engineering, Transgenic animals and their applications, In Vitro Fertilization and Embryo Transfer, Gene therapy.

Unit 5:

Application of animal cell culture technology in drug testing, cancer research, vaccine, production production of monoclonal antibodies, recombinant therapeutic proteins and other biotechnological products of industrial and medical benefits. Ethical issues in animal biotechnology.

Books/References:

1. Animal Cell Culture: A Practical Approach by R. Ian Freshney, Sixth edition, 2010, Wily-Blackwell publication
2. Animal Cell Culture by John R.W. Masters, Third Edition, 2000 Oxford University Press
3. S. B. Primrose, Molecular Biotechnology (Second Edition). 1991. Blackwell Scientific Publications Ltd.
4. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press.
5. Recent Research/Review Articles.

Paper code	Paper title	Credits	Hours
BT-510	BIOPHYSICS AND STRUCTURAL BIOLOGY	3	30

Objective: *Students will learn the physical principles of structure-function relationships in biological macromolecules such as proteins and nucleic acids, as well as the various approaches, techniques and instrumentation associated with structural biology.*

Course outcomes:

1. At the end of this course, they should be able to apply the biophysical principles and techniques to understand, model and predict biomolecular structures as well as their interactions.

Unit 1: Interactions in Biological Systems

Intra- and intermolecular forces, van der Waals, Electrostatic, and Hydrogen bonding interactions , Hydrophobic interactions, and weak interactions

Unit 2: Structure of Proteins

Conformational properties of polypeptides and Ramachandran Plot ,Primary and secondary structure , Super secondary structures, fibrous protein structures , Tertiary and Quaternary structure , Structural features of membrane proteins

Unit 3: Structure of Nucleic Acids

Conformational parameters of Nucleic acids, Chargaff's rule, DNA polymorphism, Hyperchromicity, DNA supercoiling, and Circular DNA, Types and structures of RNA, mRNA, rRNA and tRNA

Unit 4: Equilibrium and Kinetics

Folding-Unfolding equilibrium and denaturation of proteins and nucleic acids
Effect of temperature and solvent conditions on the thermodynamics of folding-unfolding equilibrium, Kinetics of protein folding

Unit 5: Techniques for Studying Macromolecular Structure and Interactions

Analytical Ultracentrifugation, Sedimentation velocity and equilibrium, determination of mol. Weights, UV-Visible Absorbance and Fluorescence spectroscopy, Circular Dichroism spectroscopy, Microcalorimetry (DSC and ITC), X-ray crystallography , Nuclear Magnetic Resonance (NMR)

Books/References:

1. Proteins: Structure and Molecular Properties by T. E. Creighton
2. Nucleic Acids: Structure, properties and function by V. A. Bloomfield and D. M. Crothers
3. Biophysical Chemistry Part I and II by C. R. Cantor and P. R. Schimmel
4. Physical Biochemistry by K. E. Van Holde
5. Physical Biochemistry by David Freifelder
6. Introduction to Protein Structure by C. Branden and J. Tooze
7. Biophysical Chemistry of Nucleic acids and Proteins by T. E. Creighton
8. Protein Physics by A. V. Finkelstein and O. B. Ptitsyn

Paper code	Paper title	Credits	Hours
BT-512	VIROLOGY	3	30

Course objectives:

Students will learn the principles of virology, virus life cycle and immune responses and its modulation during viral infection. They will also be exposed to development of drugs and vaccines. The course will emphasize on the common mechanisms used by viruses for successful reproduction, survival and spread within the host

Course outcomes:

1. The students will get an understanding of the immune responses against viral infections and the prophylactic approaches to deal with viral infections.

Unit 1: Introduction to Virology
History, Taxonomy, Baltimore classification.

Unit 2: Plant Viruses
Importance of Plant viruses, cell-to-cell movement, virus-resistant transgenic plants.

Unit 3: Virus Structure
Viral diversity with respect to structures, symmetry of viruses, triangulation number, factors governing viral capsid assembly and genome packaging.

Unit 4: Virus Attachment, Entry and Uncoating
Virus-host interactions in cellular entry, pathways involved in virus entry, uncoating of viral particles, nuclear import. Viral transmission directly from cell to cell.

Unit 5: Translation and Replication of Viral Genomes
Translation strategies- diversity and regulation, genome diversity and replication strategies, host factors influencing viral replication.

Unit 6: Virus Assembly and Egress
Intracellular trafficking, assembly within nucleus and at cellular membranes, post assembly modification and virus release.

Unit 7: Antiviral Response and Immune-evasion Strategies by Viruses
Stages of viral life-cycle that trigger immune response, modulation of immune responses, specific examples of viral immune evasion.

Unit 8: Antiviral Vaccines and Drugs
History and types of vaccines- live virus vaccines, inactivated virus vaccines and virus-like particle vaccines. Overview and mechanisms of antiviral drugs, adaptive mutations and drug resistance.

Books/References

1) Fields Virology, 6 edition, 2013,By David M. Knipe and Peter Howley
2) Plant Virology Roger Hull 5th Ed 2014
3) Principles of Virology, Fourth Edition.2015,Jane Flint, Vincent Racaniello, Glenn Rall, Anna Marie Skalka
4) Latest review articles and papers on the subject

Code	Paper title	Credits	Hours
BT-514	ADVANCED PLANT BIOTECHNOLOGY	3	30

Course objectives:

1. To introduce the students to advanced strategies in plant biotechnology with respect to managing various agronomical important traits for their improvement.

(ii) In addition to advancements for ensuring food security for all, the students are also introduced to the use of plants as biofactories for production of nutraceuticals, pharmaceuticals, industrial and other products of varied applications.

Course outcomes:

(i) From the knowledge gained through this course, the students learn to integrate various approaches required to successfully improve and produce plants for benefit of mankind.

(ii) Also, the students are able to evaluate the need and relevance of right strategy for plant improvement by following case studies and limitations encountered in their commercialization.

Unit 1: Plant Improvement via Molecular Breeding

Molecular breeding: Role of molecular markers in accelerating crop improvement, need to develop diverse types of marker systems for various crops, marker assisted selection and breeding; role of QTLs and their mapping. Case studies.

Unit 2: Molecular and Biochemical Basis of Plant Stress Resistance

Molecular and biochemical basis of plant resistance to biotic stresses, engineering plants for resistance to viruses, fungi, bacteria, weeds etc their commercialization and success stories and limitations.Molecular and biochemical basis of plant resistance to various abiotic stresses like drought, salinity, heavy metals, extreme temperatures (low/high) along with approaches to engineer plants to tolerate them, commercialization and success stories of the efforts so far.

Unit 3: Genetic Engineering Approaches for Plant Improvement

Plant Microbe interaction: Host-pathogen interaction, host-symbiont interaction, host-*Agrobacterium* interaction, scope of their exploitation for benefiting plants and mankind. Genetic Engineering Strategies in plants for quality traits, herbicide resistance, modification of nitrogen fixing capability, and achievements so far versus role of alternate strategies. Chloroplast genetic engineering: Chloroplast transformation methods and design of vectors, applications in engineering herbicide resistance, production of biopharmaceuticals, edible vaccines, and success achieved so far along with limitations.

Unit 4: Molecular Farming in Plants

Molecular farming: Advantages and scope of plants for production of nutraceuticals, edible vaccines, plantibodies, enzymes, oils and other desirable metabolites at industrial scale, development of different types of bioreactors, commercial products available and success stories so far.

Unit 5: Improved Plants for Ensuring Food for all

Ensuring World Food Security: Efforts for sustainable food production, causes of food insecurity, consumer acceptance of GM food items, social economic issues involved, limitations in ensuring food security. Current status of food security in India. Current status of GM Crops in India compared to global level.

Books/ References:

1. Slater, S, Scott, NW & Fowler, MR. (2008). Plant Biotechnology: the genetic manipulation of plants, second edition, Oxford.
2. Purohit, SD.(2013). Introduction to plant cell, tissue and organ culture, PHI Learning PVT Ltd, Delhi
3. Ramawat, KG and Goyal, S. (2014). Comprehensive Biotechnology, S Chand and Co. Pvt Ltd, Delhi
4. Articles from journals like Nature Biotechnology, Current Opinion, Trends and Annual Reviews.

Paper code	Paper title	Credits	Hours
BT-516	MOLECULAR AND CELLULAR BIOLOGY OF CANCER	3	30

Course objectives:

The objective of this course is to introduce students to a broad range of topics on fundamental cancer biology from basic research to clinical application. This course will provide students with a basic understanding of the molecular and cellular mechanisms that lead to cancer with focus on the role of growth factors, oncogenes, tumor suppressor genes, angiogenesis, and signal transduction mechanisms in tumor formation. The students will also learn fundamental principles behind cancer diagnosis, prevention, and therapeutic management.

Course outcomes:

This course will provide students with a basic understanding of the molecular and cellular mechanisms that lead to cancer with focus on the role of growth factors, oncogenes, tumor suppressor genes, angiogenesis, and signal transduction mechanisms in tumor formation. The students will also learn fundamental principles behind cancer diagnosis, prevention, and therapeutic management.

Unit 1:

Definition and description of cancer, Classification of human cancers. Trends of cancer incidence and mortality- worldwide and Indian scenario,Role of risk factors in development of cancer,Introduction to chemical, radiation, viral carcinogenesis

Unit 2:

Characteristics of cancer cells, Common cellular and molecular mechanisms that are deregulated in cancerous cells, Oncogenes and tumor suppressors, Cell cycle and cancer, Aberrant signalling in cancer, Molecular genetic alterations in cancer cells, Role of epigenetic events in tumorigenesis, Non coding RNAs and cancer

Unit 3:

Immune system and cancer, Mechanism of immune evasion by cancer cells, Introduction to immunotherapy.

Unit 4:

Cancer Diagnosis and therapy: Present methods and techniques for cancer detection, Tumor markers, Application of Genomics and Proteomics techniques in cancer diagnosis, Blood based markers for detection and screening of cancer,

Unit 5:

Biosensors in cancer diagnosis, advances in cancer treatment, Traditionalchemotherapies and chemoresistance, Noveltargetedtherapeutic approaches.

Books/ References:

- Ruddon - Cancer Biology by Raymond W. 4th Edition Oxford University Press
- Recent articles from **Nature Reviews Cancer**

Paper code	Paper title	Credits	Hours/week
BT-536	CONSTITUTION OF INDIA	NIL	2

Course objectives:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Course outcomes:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

Content

Unit 1:History of Making of the Indian Constitution
HistoryDrafting Committee, (Composition& Working)
Unit 2 :Philosophy of the Indian Constitution:
Preamble, Salient Features
Unit 3 :Contours of Constitutional Rights & Duties
Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies Directive Principles of State Policy, Fundamental Duties.
Unit 4:Organs of Governance
Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions
Unit 5:Local Administration
District's Administration head: Role and Importance,
Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.
Pachayati raj: Introduction, PRI: ZilaPachayat.
Elected officials and their roles, CEO ZilaPachayat: Position and role.
Block level: Organizational Hierarchy (Different departments),
Village level: Role of Elected and Appointed officials,
Importance of grass root democracy
Unit 6 :Election Commission
Election Commission: Role and Functioning.
Chief Election Commissioner and Election Commissioners.
State Election Commission: Role and Functioning.
Institute and Bodies for the welfare of SC/ST/OBC and women.

Books/ References:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Paper code	Paper title	Credits	Hours/week
BT-538	PEDAGOGY STUDIES	NIL	2

Course objectives:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development.

Course outcomes:

1. Understanding pedagogical practices which are being used by teachers in formal and informal classrooms in developing countries.
2. Appreciating the effectiveness of these pedagogical practices,
3. Understanding how can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy.

Unit 1: Introduction and Methodology

- Aims and rationale, Policy background, Conceptual framework andterminology
- Theories of learning, Curriculum, Teacher education.
- Conceptual framework, Research questions.
- Overview of methodology and Searching.
- Thematic overview: Pedagogical practices are being used by teachersin formal and informal classrooms in developing countries.

Unit 2: Curriculum, Teacher Education

- Evidence on the effectiveness of pedagogical practices
- Methodology for the in depth stage: quality assessment of includedstudies.
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Unit 3: Theory of Change

- Strength and nature of the body of evidence for effective pedagogicalpractices.
- Pedagogic theory and pedagogical approaches.
- Teachers' attitudes and beliefs and Pedagogic strategies.
- Professional development: alignment with classroom practices andfollow-up support
- Peer support

Unit 4: Support from the Head Teacher and the Community

- Curriculum and assessment
- Barriers to learning: limited resources and large class sizes

Unit 5: Research Gaps and Future Directions

- Research design
- Contexts
- Pedagogy
- Teacher education
- Curriculum and assessment
- Dissemination and research impact.

Books/ References:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2):245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal ofCurriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher educationresearch project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning ofbasic maths and reading in Africa: Does teacher preparation count? International JournalEducational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education.Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Paper code	Paper title	Credits	Hours/week
BT-542	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	NIL	2

Course objectives:

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

Course outcomes:

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achievethe highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

Content

Unit 1:Neetisatakam-Holistic Development of Personality

- Verses- 19,20,21,22 (wisdom)
- Verses- 29,31,32 (pride & heroism)
- Verses- 26,28,63,65 (virtue)
- Verses- 52,53,59 (dont's)
- Verses- 71,73,75,78 (do's)
- Approach to day to day work and duties.

Unit 2:Shrimad Bhagwad Geeta

- Chapter 2-Verses 41, 47,48,
- Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17,23, 35,
- Chapter 18-Verses 45, 46, 48.
- Statements of basic knowledge.
- Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68
- Chapter 12 -Verses 13, 14, 15, 16,17, 18

Unit 3:Personality of Role Model. Shrimad Bhagwad Geeta

Chapter2-Verses 17, Chapter 3-Verses 36,37,42,

- Chapter 4-Verses 18, 38,39
- Chapter18 – Verses 37,38,63

Books/ References:

1. "Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

Paper code	Paper title	Credits	Hours
IPR-102	LAW OF PATENTS	4	40

UNIT – I: Introduction

a. Evolution of Patents in India
b. International Treaties on Patents
   i. Paris Convention
   ii. TRIPS
   iii. Budapest Treaty
   iv. PCT

UNIT – II: Patentability and Procedures for Grant of Patents

a. Patentable and Non Patentable Inventions
b. Pre-requisites – Novelty, Inventive Step, Industrial Application
c. Prior Art, Anticipation, & Person Skilled in the Art
d. Procedures for Filling Application
e. Specifications – Provisional and Complete Specifications
f. Priority dates
g. Pre-Grant and Post Grant Opposition
h. Grant and sealing of Patents
i. Rights of Patentee
j. Term of Patent
k. Surrender and Revocation of patents
l. Restoration

UNIT – III: Limitations, Exceptions &Infringements

a. Licencing – Voluntary & Non –Voluntary
b. Assignment
c. Fair Use
d. Use and acquisition of inventions by Central Government
e. Parallel Imports
f. Claim Interpretations and Constructions
g. Infringements & Remedies

UNIT – IV: Patent Authorities, Patent Agents & Emerging Issues

a. Controller General of Patents
b. Patent Examiners
c. Patent Agents
d. IPAB
e. Emerging Issues
   i. Patents & Computer Programs
   ii. Business Methods & Utility Patents
   iii. Bio-Informatics Patents
   iv. Patent and Human Right Issues

Text Books:

1. *Feroz Ali* Khader, The *Law of Patents-With a Special Focus on Pharmaceuticals in India*, LexisNexis, 2nd Edition, 2011
2. Elizabeth Verkey, *Law of Patents*, Eastern Book Company, 2nd Edition, 2012

References:

1. Richard Miller, Guy Burkill, Hon Judge Birss, Douglas Campbell, *Terrell on the Law of Patents*, Sweet and Maxwell, 2010
2. *Feroz Ali* Khader, *The Touchstone Effect:The Impact Of Pre-Grant Opposition On Patents*, Lexis Nexis, 2009
3. Donald S Chisum, *Chisum on Patents* (17 Volumes), Lexis Nexis, 2012
4. Janice M. Mueller, *Patent Law*, Wolters Kluwer, 2013
5. Martin J. Adelman et al., *Patent Law in a Nutshell*, West, 2013
6. Amy L. Landers, *Understanding Patent Law*, Lexis Nexis, 2012.
7. Ananth Padmanabhan, *Intellectual Property Rights Infringement and Remedies*, Lexis Nexis, 2012

Management of Technology, Innovation and Change

Course Code: MS-102 **L-4 Credits-4**

Objective: This course is designed to help students to understand the importance of managing technology, innovation and change at the micro and macro level.

Course Contents

Unit I

Technology Management: Understanding Technology and its Relationship with Wealth of Nations and Firms Specific Knowledge; Technology Life Cycles, S- curve of Technology Evolution, Technology Strategy, Technological Planning and Forecasting, Technology Policy, Technology Generation and Development, Technology Acquisition and Absorption, Technology Transfer, Technology Exports and Joint Ventures, Global Trends in Technology Management. **(14 Hours)**

Unit II

Change Management: Understanding the Nature, Importance, Forces, Types of Technological Change; Technology Transitions; Diagnosing Organizational Capability to Change: Process, Strategy, Structure, Systems and People; Building Culture and Climate for Change and Innovation, Innovative Firms, Role of Leadership. **(14 Hours)**

Unit III

Innovations Management: Invention vs. Innovation; Types of Innovation, Innovation Strategies and Models; Concurrent Engineering; Process Innovation, Product Innovation, Building, Managing and Sustaining Innovative Organizations; Case Studies on Innovation. **(14 Hours)**

Unit IV

Creative and Lateral Thinking Management: Thinking, Creative Thinking, Myths about Creativity; Factors affecting Creativity; Creative Problem Solving: Approach and Process; MEET framework for Organizational Creativity; Managing Lateral Thinking. **(14 Hours)**

Text Books:

1. Khalil, T. M. and Shankar, R. (2012). Management of Technology: The Key to Competitiveness and Wealth Creation, 2/e, McGraw Hill Education
2. Frederick Betz (2011). Managing Technological Innovation: Competitive Advantage from change, Third Edition, John Wiley & Sons, Inc., USA

Reference Books:

1. Tushman, Michael L and Anderson P. (2004). Managing Strategic Innovation and Change, 2/e, Oxford University Press.
2. Narayanan, V. K. (2006). Managing Technology and Innovation for Competitive Advantage, Pearson Education.
3. Khurana V. K. and Saini A.K. (2017). Management of Technology and Innovation for Competitive Advantage, Ane Books, New Delhi.
4. Jauhari V. and Bhushan S. (2014). Innovation Management, 1/e, Oxford University Press.

Paper code	Paper title	Credits	Hours
IPR-106	LAW OF DESIGNS, LAYOUT DESIGNS AND GEOGRAPHICAL INDICATIONS	L4 RTDA2 C5, 40	

UNIT-I: Industrial Designs

a. Introduction
b. Evolution
c. Justification
d. International Treaties
   i. Paris Convention
   ii. Hague Agreement
   iii. Locarno Agreement
   iv. TRIPS
e. Industrial Design Act, 2000
f. Interface Between Design, Copyrights and Trademarks

UNIT-II: Semiconductor and Layout Designs

a. Introduction
b. Evolution
c. Justification
d. International Treaties:
   i. Washington Treaty
   ii. TRIPS
e. The Semiconductor Integrated Circuits Layout-Designs Act, 2000

UNIT III: Geographical Indications-I

a. Introduction
b. Evolution
c. Justification
d. International Treaties:
   i. Paris Convention
   ii. Madrid Agreement
   iii. Lisbon Agreement
   iv. TRIPS Agreement

UNIT-IV: Geographical Indications-II

a. Protection of GI at National Level
b. Geographical Indication of Goods (Protection & Registration) Act, 1999
c. Higher Level of Protection of GIs and TRIPS, Article 23 Controversy
d. Genericides of Geographical Indications

Text Books:

1. Ashwani Kumar Bansal, Design Law, Universal Law Publishing Company, 2012.
2. Latha R Nair & Rajendra Kumar, *Geographical Indications: A Search For Identity, Lexis Nexis, 2005*

References:

1. Tapan Kumar (Ed.), *WTO, TRIPS and GIs*, New Century Publications, 2014
2. Dev Gangjee, *Relocating the Law of GI*, Cambridge University Press, 2012
3. K C Kailasam and RamuVedaraman, *Law of Trademarks including International Registration under Madrid Protocol and Geographical Indications*, Lexis Nexis, 2013.

Paper code	Paper title	Credits	Hours
EM-602	AIR POLLUTION, METEOROLOGY AND CONTROL	4	40

UNIT 1: Introduction to Air Pollution

Over view of emissions, air quality and emission standards, air pollution standard index, criteria pollutants, sources and classification of air pollutants, effects of air pollution on human health, vegetation and property, primary and secondary air pollutants, global implication of air pollution (Greenhouse gases, ozone layer depletion, photochemical smog and ozone, acid rain).

UNIT 2: Air Pollution Meteorology Fundamentals

Meteorological scales of motion, environmental and adiabatic lapse rates, atmospheric boundary layer, pressure and temperature relationship in the lower atmosphere, vertical temperature variation, moisture, atmospheric stability and mixing height, temperature inversions, saturated lapse rate and cloud formation, adiabatic diagram, and wind roses.

UNIT 3: Atmospheric Diffusion Theory

Elementary overview of various atmospheric diffusion theories, steady-state atmospheric diffusion equation, diffusion models, wind speed change with elevation, Gaussian concentration distribution- Gaussian plume idea, Gaussian plume derivation as solution of the atmospheric diffusion equation, dispersion parameters in Gaussian models, Pasquill-Gifford Curves; Plume Rise –Momentum and Buoyant Plumes.

Sampling and Monitoring of Air Pollutants :

Scope, purpose and objectives of air quality monitoring; preliminary survey required for planning an air quality survey; guidelines for planning a survey; design of an air quality surveillance network; sample size; theory and principles of instruments for measurements of – ambient air pollution; andstack monitoring.

Indoor Air Pollution:

indoor air pollutants; indoor air quality model; infiltration and ventilation, control of indoor air quality.

UNIT 4: Air Pollution Control Technologies

Stationery sources,air pollution control philosophies- emission standards, emission tax and Cost-benefit, general ideas in air pollution control, alternative control measures, low NO_X combustion, control of particulate contaminants, nature of particulate contaminants, PM_{10}, $PM_{2.5}$& PM_1 particle size distribution, distribution by mass and number, behavior of particles in the atmosphere, particulate control methods and devices: Wall collections devices-selection of particulate collection device, control of gaseous contaminants: gaseous control methods and devices – absorption, adsorption, flue gas desulfurization, combustion and condensation, control of mobile sources emissions.

Text/References

1. Arcadio P. Sincero., and Gregoria A. Sicero. (2010). Environmental Engineering: A Design Approach PHI Learning Pvt. Ltd, New Delhi
2. Seinfeld, J. H. (1986). Atmospheric Chemistry and Physics of Air Pollution, Wiley Inter-science, New York.
3. Stern, A. C. (2004). Air Pollution, Vol. 1-VIII, Academic Press.
4. M. N. Rao. (1993). McGraw Hill, McGraw Hill.
5. Bruno Sportisse (2010), Fundamentals in Air Pollution – From Processes to Modelling, Springer.
6. Perkins, H. C. (1974). Air Pollution, McGraw-Hill, New York.
7. J. W. Samuel., (1971), Fundamentals of Air Pollution, Samuel, Addison Wesley Publishing Company.

Paper code	Paper title	Credits	Hours
BT-526	ABIOTIC AND BIOTIC STRESS BIOLOGY	4	40

Course objectives:

1. *To gain knowledge about plant responses to abiotic and biotic stress*
2. *To understand the mechanisms responsible for stress tolerance*
3. *To study various research approaches for crop improvements*
4. *To study the factors causing injury during stress.*

Course outcomes:

1. *Understanding of plant responses to various stresses at physiological, biochemical and molecular level.*
2. *Understanding of plant stress tolerance mechanisms.*
3. *Genetic engineering approaches for crop improvements will be understood.*
4. *Factors involved in causing injury during stress will be identified.*

Unit 1: Review of Plant Nutrients and Hormones

Review of water uptake; Introduction to plant nutrition; Mineral availability- uptake of minerals; Plant response to nutrients;– Phytohormones - Roles of auxins, cytokinins, gibberillins, abscisic acid, ethylene, Jasmonates

Unit 2: – Photoperiodism

Introduction to light - properties and responses; Canopy response to light - Canopy closure and yield potential - Red and Far Red light – Photomorphorgeneis, Phytochrome responses, Blue light responses

Unit 3: Photosynthesis and Photorespiration

Review of C3, C4 and CAM photosynthesis - Stomatal mechanics and mechanisms - Plants and Clocks, Circadian rhythms, Temperature Responses, Vernalization and dormancy

Unit 4: Abiotic Stress

Acclimation and crop adaptation to water stress – salinity stress – temperature stress – heat and cold – Photo oxidative stress – nutrient stress – heavy metal stress – stress signaling - metabolite engineering for abiotic stress tolerance – functional genomics of stress tolerance

Unit 5: Biotic Stress

Plant response to pathogens and herbivores – biochemical and molecular basis of host plant resistance – toxins of fungi and bacteria – systemic and induced resistance – pathogen derived resistance – signaling - gene for gene hypothesis – genetic engineering for biotic stress resistance – gene pyramiding

Books / References

1. U. Chakraborty, Bishwanath Chakraborty, 2005. Stress biology, Vidhyasekaran, P. 2007. Narosa Publishing House
2 Taiz and Zeiger, Plant Physiology, 3rd Edition, Panima Publishing Corporation, New Delhi, 2003.
3. Buchnan, B. B., Gruissem, W. and Jones, R. L., Biochemistry and molecular biology of plants. American Society for Plant Physiologists, Rockville, USA. 2000.
4. Gatehouse, A. M .R., Hilder, V. A. and Boulter, D., Plant Genetic manipulation for crop protection In: Biotechnology in Agriculture Series (Eds.) Vol. 7 CAB International, Wallingford, UK. 266p. 1992
5. Panda N. and G.S.Khush, Host plant resistance to insects. CAB International, Walling Ford. 431p, 1995
6. Slater, A., Scott, N. and Fowler, M., Plant biotechnology -The genetic manipulations of plants. Oxford University press. 346p. 2003.
7. Vidhyasekaran, P., Fungal pathogenesis in plants and crops: Molecular biology and host defense mechanisms, Marcel Dekkar Inc., New York. 624p, 1997

Code	Paper title	Credits	Hours
BT-528	BIOETHICS, BIOSAFETY AND IPR	4	40

Course objectives:

To apprise the students of the various societal, governance and regulatory issues in biotechnology with special emphasis on ethics, safety and intellectual property rights. Through this course, the students develop a perspective on the importance of these aspects in the success of biotechnology products and services in the market.

Course outcomes:

1. *Understand research problem formulation w.r.t. safety , ethics and IPR*
2. *Analyze research related information*
3. *Follow research ethics, safety w.r.t. biotechnology*

Unit 1: Bioethics

Biotechnology and Society, perceptions of the consumers, government, industry, media and civil society; globalization and harmonization of regulatory regimes for bioethics, biosafety and IPR in biotechnology; Convention on biological Diversity, UN Declaration on bioethics and human rights, ethics policies for biotechnology in India, Responsible Conduct of Research, misconduct, Falsification, fabrication, plagiarism, conflict of interest, regulatory misconduct, implications for public trust in biotechnology

Unit 2: Biosafety

Concepts, biosafety in the laboratory, institution, state and national level, risk groups and biosafety levels, food and environmental safety, regulatory procedures in India, DBT guidelines for recombinant DNA research and biocontainment (2017), International biosafety obligations: Cartagena Protocol, biological warfare and bioterrorism

Unit 3: Intellectual Property Rights

Patents, copyrights, trademarks, designs and circuits, geographical indications, plant protection and trade secrets, their scope and duration of protection, their international harmonisation and transition from national to WTO regime, current domestic and global scenario

Unit 4: Patents in Biotechnology

Patentable subject matter, procedure of patenting, products and processes, novelty, non-obviousness, utility, enablement, disclosure/deposit, IPR in agriculture: Plant variety Protection, Plant Patents and Utility patents

Unit 5:

Strategic aspects of patent filing locally and abroad, PCT, TRIPS+, FTAs, patent litigation

Books/References:

1. Encyclopedia of Bioethics
2. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH.
3. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and Safety Assessment (3rd Ed). Academic Press.
4. Fleming, D.A., Hunt, D.L., (2000). Biological safety Principles and practices (3rd Ed). ASM Press.
5. The law and strategy of Biotechnological patents by Sibley. Butterworth publications
6. Websites of WIPO (IPR), DBT (Biosafety) CBD (Cartagena protocol), UNESCO (bioethics)
7. Recent reviews/articles from literature.

Code	Pater title	Credits	Hours
BT-530	ADVANCED DOWNSTREAM PROCESSING	4	40

Course objectives:

This course is meant to develop an understanding on the various aspects of product recovery with a special focus on industrial scale processes in biotechnology and the relevant theory, techniques and equipment involved, from an engineer's perspective. It equips the student with the basic tools and training for an industrial career.

Course outcomes:

The students will be able to appreciate and design downstream processing strategies independently for a system.

Unit 1: Properties of Bio-Molecules as Basis of Separation

Design of batch & continuous systems

PRINCIPLES OF SOLID LIQUID SEPARATION;

Filtration, Centrifugation, Membrane based separation

Unit 2: Theory & Design of Equipment

Extractive separation, Solvent based separation, Design of multistage equipment based on partition coefficient, Aqueous 2-phase separation, Chromatographic separation
Equilibrium theory & column design, Non-linear & mass transfer effects
Loading effects, Non-linear absorption isotherms and scale up

Unit 3: Contnuous Chromatography and SMB Technology

Theoretical and Practical aspects
Industrial applications

CELL DISRUPTION METHODS

Handling intracellular & extracellular products of fermentation

Unit 4: Crystallization

Principles
Scale up
Equipment design

DRYING

Principles
Equipment design

Unit 5: QBD Principle& Practices

INTEGRATED PROCESS DESIGN

Sequencing & interfacing of unit operations
Flow sheets with mass & energy balances
Examples: Rec-protein purification from IB & Intracellular soluble fraction

Books/References:

1. Bioseparation science and engineering. Roger Harrison, Paul Todd etal, Oxford Univ. Press.
2. Transport processes and separation process principles. 4th Ed. Christie John Geankoplis, PHI-EEE
3. Handbook of downstream processing, by Goldberg, Springer.
4. Downstream processing in biotechnology (2013). By Wisselingh and Krijgsman Duff. Academic Press.

Code	Paper title	Credits	Hours
BT-532	**BIOPROCESS MODELLING AND CONTROL**	**4**	**40**

Course objectives:

This course is complementary to the biochemical engineering course, which deals with abiotic phase modelling, while this course is focused on the biotic phase modeling. The emphasis is on quantitative analysis of cell growth, product formation, stoichiometry, energetic and kinetics, as well as on the implementation of biotic phase models in different modes of bioreactor operations, like batch, fed-batch and continuous systems. The course moves beyond black box models to structured models in order to get a better understanding of cell behaviour. Students are also introduced to control theory, with emphasis on bioprocess control. A prior exposure of the student to fundamentals of bioprocess engineering and process control is desirable, though not essential. However, a background in mathematics such as calculus is essential.

Course outcomes:

At the end of the course, the students should be able to develop comprehensive models of cellular behaviour in bioreactors, in order to predict their performance as well as optimize and control operations.

1. **MACROSCOPIC THEORY FOR OPEN SYSTEMS:**
   - 1.1. Conserved and non-conserved quantities
   - 1.2. Balance equations for the chemical state vector of a system
   - 1.3. Elemental mass balancing
   - 1.4. Balance of energy and entropy

2. **STOICHIOMETRY AND ENERGETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION:**
   - 2.1. Elementary balance equations for biomass
     - 2.1.1. Growth without product formation
     - 2.1.2. Anaerobic growth without external e^- acceptors or with e^- acceptors other than o_2
   - 2.2. Thermodynamic treatment of the energetic of growth
     - 2.2.1. Enthalpy and free energy changes during growth
     - 2.2.2. Thermodynamic efficiency
     - 2.2.3. Aerobic and anaerobic growth
     - 2.2.4. Energy availability in various oxidation/reduction reactions

3. **THE LINEAR EQUATION FOR SUBSTRATE CONSUMPTION:**
   - 3.1. The concept of maintenance energy
   - 3.2. Aerobic growth without product formation with maintenance
   - 3.3. Anaerobic growth with maintenance
   - 3.4. Calculation of true yields and maintenance during anaerobic and aerobic growth
   - 3.5. Biochemically structured balances of microbial metabolism
   - 3.6. Concept of ATP yield of growth
   - 3.7. Aerobic growth, the p/o ratio
   - 3.8. Biochemically structured model of aerobic growth on one substrate
   - 3.9. Growth on mixed substrates
   - 3.10. Growth with formation of product under anaerobic and partially aerobic conditions

4. **KINETICS OF SUBSTRATE UTILIZATION, PRODUCT FORMATION, AND BIOMASS PRODUCTION IN CELL CULTURES:**
   - 4.1. Ideal reactors for kinetics measurements
     - 4.1.1. The ideal batch reactor
     - 4.1.2. The ideal continuous-flow stirred-tank reactor (CSTR)
   - 4.2. Kinetics of balanced growth
     - 4.2.1. Monod growth kinetics
     - 4.2.2. Kinetic implications of endogenous and maintenance metabolism
     - 4.2.3. Other forms of growth kinetics
     - 4.2.4. Other environmental effects on growth kinetics
   - 4.3. Transient growth kinetics
     - 4.3.1. Growth-cycle phases for batch cultivation
     - 4.3.2. Unstructured batch growth models
     - 4.3.3. Growth of filamentous organisms

5. **STRUCTURED KINETIC MODELS:**
   - 5.1. Compartmental models
   - 5.2. Metabolic models
   - 5.3. Modeling cell growth as an optimum process

6. **PRODUCT FORMATION KINETICS:**
   - 6.1. Unstructured models
     - 6.1.1. Parameter estimation for a simple batch fermentation
   - 6.2. Chemically structured product formation kinetics models
   - 6.3. Product formation kinetics based on molecular mechanisms: genetically structured models
   - 6.4. Product formation kinetics by filamentous organisms
   - 6.5. Segregated kinetic models of growth and product formation

7. **DESIGN AND ANALYSIS OF BIOREACTORS:**
   - 7.1. Ideal and non-ideal reactors
   - 7.2. Mixing time and residence time distributions in reactors
   - 7.3. CSTRS with wall growth, with recycle and in-series
   - 7.4. Fed-batch reactor operation and design of feeding profiles

8. **INSTRUMENTATION AND CONTROL:**
   - 8.1. Physical and chemical sensors for the medium and gases
     - 8.1.1. Sensors of the physical environment
     - 8.1.2. Medium chemical sensors
     - 8.1.3. Gas analysis
   - 8.2. On-line sensors for cell properties
   - 8.3. Off-line analytical methods
     - 8.3.1. Measurements of medium properties
     - 8.3.2. Analysis of cell population composition
   - 8.4. Data analysis
     - 8.4.1. Data smoothing and interpolation
     - 8.4.2. State and parameter estimation
   - 8.5. Process control
     - 8.5.1. Direct regulatory control
     - 8.5.2. Cascade control of metabolism
   - 8.6. Advanced control strategies
     - 8.6.1. Programmed batch bioreaction
     - 8.6.2. Design and operating strategies for batch plants
     - 8.6.3. Continuous process control

9. **LAPLACE-DOMAIN ANALYSIS OF ADVANCED CONTROL SYSTEMS:**
   - 9.1. Cascade control
     - 9.1.1. Series cascade
     - 9.1.2. Parallel cascade
   - 9.2. Feed-forward control
     - 9.2.1. Linear feed-forward control
     - 9.2.2. Nonlinear feed-forward control
   - 9.3. Open loop-unstable processes
     - 9.3.1. Simple systems
     - 9.3.2. Effects of lags
     - 9.3.3. Pd control
     - 9.3.4. Effect of reactor scale-up on controllability
   - 9.4. Processes with inverse response
   - 9.5. Model-based control
     - 9.5.1. Direct synthesis
     - 9.5.2. Internal model control

Books/References:

1. New Directions in Bioprocess Modeling and Control: Maximizing Process Analytical Technology, 2006, Michael A. Boudreau , Gregory K. McMillan
2. Bioprocess Technology: Kinetics and Reactors Anton Moser

Paper code	Paper title	Credits	Hours
BT-534	STATISTICAL METHODS IN ENGINEERING AND TECHNOLOGY	4	40

Course objectives:

1. To learn data handling, analysis and interpretation of the results.
2. To know the mathematical tools for data analysis and experimental design.
3. To independently design experiments for statistically significant outcomes.

Course outcomes:

1. The student is expected to independently design an experiment through statistical approach.
2. The student is expected to be able to analyze the statistical significance of experimental data and interpret his results.

Unit 1:Probability Distribution:
Introduction to probability and laws of probability, Random Events, Events-exhaustive, Mutually exclusive and equally likely (with simple exercises), Definition and properties of binomial distribution, poisson distribution and normal distribution.

Unit 2: Statistical hypothesis testing:
Making assumption, Null and alternate hypothesis, error in hypothesis testing, confidence interval, one-tailed and two-tailed testing, decision making. Tests of Significance: Sampling distribution of mean and standard error, Large sample tests - test for an assumed mean and equality of two population means with known S.D., z-test; Small sample tests- t-test for an assumed mean and equality of means of two populations when sample observations are independent; Parametric and Non parametric tests (Mann-Whitney test); paired and unpaired t-test, chi square test.

Unit 3: Analysis of Variance:
The Analysis of Variance (ANOVA), Model Adequacy Checking, Interpretation of Results, Determining Sample Size, Single-Factor Experiments, The Random Effects Model, The Regression Approach to the Analysis of Variance, Nonparametric Methods in the Analysis of Variance.

Unit 4: Design of Experiments:
Randomized Complete Block Design (RCBD) , Latin Square Design, Balanced Incomplete Block Designs (BIBD), Factorial designs.

Unit 5: Response Surface Methods (RSM) and Designs:
Design of experiments using RSM, Method of Steepest Ascent, Analysis of a Second-Order Response Surface, Experimental Designs for Fitting Response Surfaces.

Text books / reference books:

1. Methods in Biostatistics for Medical Students and Research Workers (English), Jaype Brothers, 7th Edition, 2011
2. Statistical methods in biology by Norman T.J. Bailey, Cambridge University Press 3rd Edition, 1995.
3. Biostatistics by P. N. Arora and P. K. Malhan, Himalaya Publishing House, 2nd Edition, 2006.
4. Biostatistical analysis. Jerold Zar, Pearson Education, 4th Edition.
5. Biostatistics; A foundation for analysis in the Health Sciences, Wiley, 7th Edition.
6. ML Samuels, JA Witmer Statistics for the Life Sciences, 3rd edition. Prentice Hall, 2003.

Paper code	Paper title	Credits	Hours
BT-601	BIO MANUFACTURING PRINCIPLES AND PRACTICES	3	30

Course Objective: *This course will help students to develop conceptual clarity and knowledge about systems which brings and guarantee quality in products (Biopharmaceuticals, diagnostics and foods) manufactured for human use. The knowledge of GMP and GLP requirements is critical for students who opt for careers in biomanufacturing.*

Course outcomes:

The student will be able to have a general idea about the manufacturing processes and the quality systems adopted / implemented in each case.

1. BIOMANUFACTURING PRINCIPLES:

1.1. Overview and design of biomanufacturing, quality by design approach, technical considerations, phases and scale up: life cycle of manufacturing, raw material considerations, compliance and quality in biomanufacturing, lean biomanufacturing;

1.2. Process analytical technology (PAT) during biomanufacturing: background and need tools for data acquisitions (software in fermenters, flow filtrations, chromatography, analysis and design process analyzers, process control tools and continuous improvement and knowledge management;

1.3. Standard manufacturing operating procedures of biotechnology, including upstream and downstream processing of proteins, and quality control of protein production, and final fill and finish of product;

1.4. Case studies to be included at least: therapeutic proteins, monoclonal antibodies, human vaccines.

2.1 QUALITY SYSTEM:

2.2 Introduction to quality system, main elements of a quality system

2.3 Essential of quality system

2.4 Practical implementation of a quality system

2.5 Structure of quality manual, correlation between GMP requirements (WHO) and ISO 9001:2000

3. PRINCIPLES AND PRACTICE OF (GOOD MANUFACTURING PRACTICE) GMP

3.1 Personnel, Premises, Facilities and Equipment: Principles of human resource management, duties of senior management, organizational structures, qualification and profiles requirement, workplace and job descriptions, material & personnel flow and layout, air cleanliness classes and grades, construction elements, barrier systems, isolators and safety cabinets, building services, heating ventilation air conditioning (HVAC), process gases, qualification of premises and HVAC systems, pharma monitoring of HVAC systems, particle monitoring, Facility planning, materials, hygienic design in solids handling, system controllers and process control systems, technical documentation, calibration, maintenance, cleaning of facilities, containment (personnel protection) in solids handling

3.2 Pharmaceutical water: Water qualities, generation of pharmaceutical water, distribution and storage of pharmaceutical water, qualification of water supplies, operation of water supplies, pure steam systems

3.3 Qualification: Official requirements, preparation of the qualification, qualification documentation, design qualification (DQ), Installation qualification (IQ), operational qualification (OQ), Performance qualification (PQ), special cases of qualification

3.4 Process and cleaning Validation: Official requirements, Validation - a key element of quality management, validation planning and procedure, validation documentation, process validation and product lifecycle, how to validate cleaning procedures, cleaning validation master plan, establishing the scope of validation, acceptance criteria and limit calculation

3.5 Computer system Validation: Introduction and terminology, legal aspects, system life cycle, system classification and risk management, validation of computerised systems

3.6 Quality Risk Management: Principles and requirements, Potential applications and uses of quality risk management, the quality risk management process, methods and tools of quality risk management

3.7 Production: Sanitation, personnel hygiene, production hygiene, sanitation programme. environmental monitoring, GMP in the production process, weigh-in, identification, in-process control prevention of cross-contamination

3.8 Sterile Production and Packaging: Introduction, Air lock concepts, manufacture of terminally sterilised products, sterilisation processes, aseptic processing, freeze-drying, testing for sterility, testing for endotoxins, testing for leakage and for particles, microbiological monitoring

3.9 Laboratory Controls: Sampling, substances used in laboratories, qualifying laboratory instruments, calibration in the lab, validation of analytical methods, stability testing, test results outside defined criteria (OOX), raw data documentation, batch release, microbiological testing, pharmacopoeias, laboratory data management systems (LDMS)

3.10 Documentation: Official requirements, GMP-compliant documentation, batch documentation, standard operating procedures (SOPs), site master file, electronic batch recording and batch release, document management systems

3.11 Inspections: Principles, inspection procedures, inspectors, organization of inspections, self-inspection, inspection of contract manufacturers, inspection of suppliers, questionnaire for preparing GMP-inspections, Inspection of API manufacturers

3.12 Active Pharmaceutical Ingredients: Introduction, regulatory principles, marketing authorisation documentation for active substances, GMP certificates, auditing active substance manufacturers, chemical active substances, biotechnological active substances

4. **GMP IN REGULATION**

4.1. Information, national bodies and pharmaceutical associations

4.2. EU directives and guidelines, USA: CFR and FDA guidelines, ICH-guidelines, PIC/S guidelines, GMP of other regions, WHO guidelines

Books/References:

1. Introduction to Biomanufacturing. By Northeast Biomanufacturing Center and collaboration, 2012.
2. Introduction to Biomanufacturing, by Mark Witcher. In Encyclopedia of Industrial Biotechnology.
3. Good Manufacturing Practices for Pharmaceuticals (e-resource): A plan for total quality control. Sidney Willig and James Stoker.
4. Biotechnology Operations: Principles and Practices; by John M. Centanni, Michael J. Roy; CRC press
5. Lean Biomanufacturing, 1st Edition; Author Nigel Smart; Woodhead Publishing
6. GMP manual; Publisher Maas &Peither America, Inc. GMP Publishing

Paper code	Paper title	Credits	Hours
BT-603	SYSTEMS AND SYNTHETIC BIOLOGY	3	30

Course objectives:
To develop an understanding on gene functions, intracellular flux and cellular networks in cells. This will provide a quantitative basis, based on thermodynamics, enzyme kinetics, metabolic flux analysis and metabolic control analysis, for understanding of metabolic networks in single cells and at organ level for successful implementation of concepts in synthetic biology.

Course outcomes:
Understand the general principles of metabolic engineering and be able to implement the concepts of metabolic engineering in different systems.

Unit 1: Introduction:

Stoichiometry, Kinetics and Thermodynamics Of Cellular Reaction.Material balances on pathways and whole cell balances; Over and under-determined systems; Data consistency for over-determined systems.

Unit 2: Regulation and manipulation of Metabolic Pathways:

Regulation of metabolic pathways; role of enzymes, substrate, product and regulatory molecules; Hierarchical control in cellular systems.Pathway manipulation strategies for overproduction of various metabolites, examples of ethanol overproduction, overproduction of intermediates in main glycolytic pathway and TCA cycle like pyruvate, succinate etc.; Need for multiple genomic modifications; Modulating fluxes in desired pathways; Tools for multiple genomic modifications examples-TALENS CRISPR-Cas systems as well as traditional systems of gene knock ins and knock outs and promoter engineering.

Unit 3: Synthetic Biology:

Metabolic pathway synthesis; Relation with bioprocess design; BIOBRICKS approaches; Introduction to tools of synthetic biology.

Unit 4: Metabolic Pathway Synthesis & Flux Analysis:

Metabolic flux analysis; Building stoichiometric matrix; Steady state and pseudo steady state assumptions; Using different optimizing functions to solve linear programming problem; FBA, understanding flux cone and constraints; Introducing additional constraints from thermodynamics; Brief introduction to developments in this area; MOMA (Minimization of Metabolic Adjustment), iFBA (Integrated Flux Balance Analysis) etc

Unit 5: Determination and Application of Metabolic Flux:

Experimental determination of metabolic fluxes; C13 labeling, NMR and GC-MS based methods for flux determination.

Books/References:

1. Stephanopoulos, G.N., Aristidou, A.A., Nielsen, J. (1998) Metabolic Engineering: Principles and Methodologies. 1st ed. San Diego: Academic Press.
2. Smolke, C.S. (2010) Metabolic Pathway Engineering Handbook: Fundamentals. 1st ed. New York: CRC Press.
3. Smolke, C.S. (2010) Metabolic Pathway Engineering Handbook: Tools and Applications. 1st ed. New York: CRC Press.

Paper code	Paper title	Credits	Hours
BT-605	BIOPRODUCT DEVELOPMENT AND BIOENTREPRENEURSHIP	3	30

Course objectives:

1. To provide knowledge on the social studies of science, technology and economy.
2. to build concepts associated with entrepreneurship, business, and economic and social development through biotechnology.
3. To know the national and international regulatory framework and growth potential in the world market.

Course outcomes:

1. Through this course, the students develop a perspective on the importance of interdisciplinary influences in the success of biotechnology products and services in the market and build on them further or apply them in a business environment.
2. To have a holistic picture of an business environment with reference to biotechnology product and services.

Unit 1:

Understanding Biotechnology Entrepreneurship, The biotechnology Industry, essential elements for growing biotechnology clusters. Biotechnology product sectors, Technology opportunities, evaluating ideas, Commercialization of Bio-agricultural Products, Biotechnology Business Models, Risk Management.

Unit 2:

Company Formation, Ownership Structure, and Securities Issues, Licensing the Technology: Biotechnology Commercialization Strategies Using University and Government Labs, Intellectual Property Protection Strategies for Biotechnology Innovations.

Unit 3:

Biotechnology Products and their Customers, Developing a Successful Market Strategy, Biotechnology Product Coverage, Coding, and Reimbursement Strategies, Public Relations Strategies to Support Biotechnology Business Goals.

Unit 4:

Biotechnology Product Development, Therapeutic drug development & clinical trials, Development & commercialization of in vitro diagnostics, Regulatory Approval and Compliances for Biotechnology Products, Biomanufacturing of Biotechnology Products.

Unit 5:

Company Growth Stages and the Value of Corporate Culture, Ethical Considerations for Biotechnology Entrepreneurs.

Text books / Reference books:

1. Mauborgne, René, Blue Ocean Strategy (Expanded Edition), Boston: Harvard Business School Press; 2015. ISBN: 978-1-59139-619-2.
2. Schrage, Michael, The Innovator's Hypothesis, Boston: MIT Press; 2014. ISBN: 978-0-262-02836-3.
3. Westerman et al., Leading Digital, Boston: Harvard Business School Press; 2014. ISBN : 9781625272478.
4. Web-resources and suggested reviews/ research papers.

Paper code	Paper title	Credits	Hours
BT-607	BIOINFORMATICS	4	40

Course objectives:

1. The basic objective is to give students an introduction to the practical techniques of bioinformatics.
2.The students are expected to learn the use of a wide variety of internet applications, biological database and will be able to apply these methods to research problems.

Course outcomes:

1. Students should be able to locate and extract data from key bioinformatics databases and resources as well as tools used to annotate features on a biomolecule.
2. Interpret computational analysis results and what can be inferred from them biologically.

Unit-1: Biological Databases, Sequence Alignment and Database Searching:
Evolutionary basis of sequence alignment, Optimal alignment methods, Substitution scores & gap penalties, Statistical significance of alignments, Database similarity searching, FASTA, BLAST, Low complexity regions, Repetitive elements, Multiple Sequence Alignment: Progressive alignment methods, Motifs and patterns, Clustal, Muscle, etc. Scoring matrices, Distance matrices.

Unit-2:
Alignment, tree building and tree evaluation, Comparison and application of UPGMA, NJ, MP, ML methods, Bootstrapping, Jackknife. Software for Phylogenetic analysis. DNA barcoding and molecular phylogeny: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, CBOL recommendations, BOLD.

Unit-3: Structural Biology:
3-D structure visualization and simulation, Basic concepts in molecular modeling: different types of computer representations of molecules. External coordinates and Internal Coordinates, Molecular Mechanics, Force fields etc. Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles, Ramachandran map.

Unit-4: DNA & RNA secondary and tertiary structures, t-RNA tertiary structure. Protien Secondary structure prediction:
Algorithms viz. Chou Fasman, GOR methods, Tertiary Structure prediction.

Unit-5:
Methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology/comparative Modeling, fold recognition, threading approaches, and ab initio structure prediction methods. CASP. Computational design of Promoters, Proteins & other molecules.

Books / Reference:

1. Bioinformatics: A practical guide to the analysis of genes and proteins A.D. Baxevanis and B.F.F. Ouellette (Eds). 2002 John Wiley and Sons.
2. Bioinformatics: Sequence and Genome Analysis by D.W. Mount, 2001, Cold Spring Harbor Laboratory Press.
3. Introduction to Bioinformatics Algorithms; Jones &Peuzner; Ane Books, India.
4. Microarray Bioinformatics; DovStekel; Cambridge University Press.
5. Web-resources and suggested reviews/ research papers.

Paper code	Paper title	Credits	Hours
BT-609	WASTE TO ENERGY	4	40

Course objectives:

1. To understand the importance of utilizing waste as a part of waste management.
2. To understand the potential of waste as energy resource and how to utilize it.
3. To know how to utilize biomass for energy production.

Course outcomes:

1. To be able to appreciate the design, construction and operation different processes in biomass conversion.
2. To be able to design waste management systems in the light of waste to energy concept.

Unit-1: Introduction to Energy from Waste:
Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

Unit-2: Biomass Pyrolysis:
Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-3: Biomass Gasification:
Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit-4: Biomass Combustion:
Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-5: Biogas:
Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Books / Reference:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

Paper code	Paper title	Credits	Hours
BT-611	BIODIVERSITY AND BIOTECHNOLOGY	4	40

Course objectives:

(i) to make the students aware of the need to evaluate, manage and conserve biodiversity and various biotechnological approaches available to achieve this.

(ii) To introduce them to consequences of indiscriminate and unethical exploitation of these resources and also the laws in place to tackle problems arising out of it.

Course outcomes:

i) to develop a perspective among students on the role of biodiversity as the feedstock for biotechnology and also as an essential natural resource for environmental sustainability, ecosystem services and livelihoods.

(ii) Students also learn about biodiversity identification, conservation, bio-prospecting, access and benefit sharing and the related national and international legal and policy regimes to fit into academic and regulatory roles.

Unit 1: Concepts and principles of biodiversity

Origin of biodiversity/evolution, definition of biodiversity, types of biodiversity, levels of biodiversity, genetic resources, conservation of biodiversity, endangered species, impact of pollution on biodiversity, loss of biodiversity.

Unit 2: Germplasm and biodiversity conservation

Germplasm and its conservation, classical and new approaches to conservation, collection and exchange of germplasm, cryopreservation, stability of conserved germplasm.
Conservation of biodiversity, Need for conservation of biodiversity, types of conservation, role of biotechnology in biodiversity conservation, in vitro conservation, application of in vitro conservation, limitation of in vitro conservation.

Unit 3: Loss of biodiversity and its management

Economic importance of biodiversity, Bioprospecting of microbial, animal and plant biodiversity resources of India, scope of new sources of alternative foods, medicine etc.
Causes and consequences of biodiversity loss, habitat loss and alteration, endangered species/exotic species, effect of pollutants on species loss, loss of genetic diversity, preventing biodiversity loss.
Management of biodiversity,identifying land for natural resources, managing wild life resources, biodiversity in a changing world, wealth of nature.

Unit 4: Tools to study bio-diversity

DNA extraction from difficult species and preserved specimens; *Screening methods:* introduction of different types of molecular markers used for characterization of biodiversity. *DATA analysis:* measure of polymorphisms within and among populations, dendrograms.

Unit 5: Laws to protect and regulate utilization of biodiversity

National environmental policy act, endangered species Act, national biodiversity authority (NBDA), plant variety protection & regulatory authority (PVPRA) Internal, Laws and special problems in developing countries.

Books/References:

1. Plant biotechnology and Biodiversity Conservation by U. Kumar and A.K. Sharma published by *Agrobios* (India),(2008)
2. Essentials of conservation Biology 6th Edition by Richard B. Primack; Sinauer Associates, *Inc. Publishers*. W.K.(2014)
3. Molecular tools for Screening Biodiversity Edited by. Angela Karp, Peter G. Isaac and David S. Ingram published by *Chapman & Hall*. (1998)

Paper code	Paper title	Credits	Hrs/sem
EM-701	EIA & RISK ANALYSIS	4	40

UNIT-I: Introduction to EIA:
Definition , scope and development of EIA, purpose, objectives and basic principles of EIA, Types of EIA, Strategic environmental assessment (SEA); History of EIA in India - EIA Gazette Notification, 1994 & 2006 – Category A & Category B Projects, Prior Environment clearance(EC) requirements and stages. General EIA methodology; Establishing the environmental baseline.

UNIT-II: EIA methodology:
Screening- criteria, siting guidelines, prohibited zones; Scoping: Identification of Valued Environmental Components (VEC), Impact Identification -Checklists, matrices, qualitative methods, networks and overlay maps; Impact prediction- prediction models for impacts on air, water, soil and biological environment , Impact evaluation -multi attribute utility theory, environmental evaluation system- Cost benefit analysis, Economic valuation of intangible environmental impacts, Social impact assessment

UNIT-III: Impact mitigation, monitoring & audit:
Mitigation methods and approaches, Appraisal, review, Decision making, Public consultation and participation, monitoring and auditing in EIA process, various forms of audit, Environment management plan (EMP), Environmental Impact Statement (EIS), Post-clearance Monitoring Protocol. Comparison of EIA in different countries.

Case studies: EIA of thermal power plant, pulp and paper mills, river valley projects, mining projects, urbanization and linear development.

UNIT-IV: Risk analysis and Environmental management:
Definition of risk, environmental risk analysis, fundamentals of hazard, exposure and risk assessment, basic steps in risk assessment, hazard identification, dose response assessment, risk characterization, quantified risk assessment for industrial accidents, design of risk management program, risk assessment application to environmental management problems.

Recommended Books:

1. John Glasson, RikiTherivel and Andrew Chadwick. 2005. Introduction to Environmental Impact Assessment, 2nd Ed., UCL Press, Philadelphia, USA
2. Canter, Larry W. 1996. Environment Impact Assessment. McGraw-Hill.
3. Rau, G.J. and C.D. Weeten. 1980. Environmental Impact Analysis Handbook McGraw Hill.
4. D. P. Lawrence. 2003. Environmental Impact Assessment, Practical Solutions to Recurrent Problems, John Wiley and Sons.
5. Y. Anjanvelu. 2002 Environmental Impact Assessment Methodologies, B.S.Publications,
6. D. P. Lawrence, 2003. Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley and Sons.
7. Eccleston, C.H. 2011. Environmental Impact Assessment, Taylor & Francis
8. Peter Wathem 2013. Environmental Impact Assessment : Theory and Practice , Taylor & Francis