DEPARTMENT OF BIOTECHNOLOGY

ANNA UNIVERSITY, CHENNAI

Vision:

The Department of Biotechnology is committed to evolve as a world class science and technology center by integrating quality and ethics in teaching and research.

Mission:

The mission of the department is

- To provide students a unique and multidisciplinary learning experience that will foster the young minds to develop as a researcher, entrepreneur etc.
- To enhance academic and industrial collaborative research initiatives for the development of biotechnological, food and therapeutic products.
- To emphasise and equip the students towards innovative industrial and research updates.
- To serve the society with utmost commitment, integrity, enthusiasm, and dedication.

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ANNA UNIVERSITY: :CHENNAI – 600 025

UNIVERSITY DEPARTMENTS

M. TECH. BIOTECHNOLOGY

REGULATIONS – 2019

CHOICE BASED CREDIT SYSTEM

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. To prepare students to excel in research and to succeed in Biotechnology research or industry through the latest state-of-art postgraduate education.
2. To provide students with solid fundamentals and strong foundation in statistical, scientific and engineering subjects required to create and innovate in the field of biotechnology.
3. To train students with good scientific and technical knowledge so as to comprehend, analyze, design, and create novel products and solutions for developing novel therapeutics and enzymes.
4. To sensitize students about scientific temper and the necessity of not only professional ethics but also bioethics.
5. This course also enables the student to develop good communication skills not only in scientific field but also for the workplace. The students are trained to be team workers, develop organizational skills.
6. The course has a multidisciplinary approach, and therefore the student is able to choose various options in Biotechnology, Pharmaceutical technology and Food Technology
7. To provide students with an academic environment, social responsibility and awareness of the environment.
8. Finally to develop excellence in leadership skills, respect for authority, loyalty and the life-long learning needed for a successful scientific and professional career

2. PROGRAMME OUTCOMES (POs)

After going through the two years of study, our Post Graduates will exhibit ability to

PO	Post Graduate Attribute	Program Outcome
1	Engineering Knowledge	Graduates will demonstrate good knowledge of Statistics, Science and Technology to solve engineering and research problems
2	Problem Analysis	They will be able to demonstrate and able to independently perform experiments in areas of Bioprocess, Enzyme Technology, Genetic Engineering, Animal Biotechnology and Immunotechnology
3	Design/development of solutions	They will be able to design and conduct experiments, analyze and interpret data
4	Conduct investigations of complex Problems	The graduates will be capable of demonstrating an ability to design an experiment, component or process as per needs and specifications.
5	Modern tool usage	The graduate will be adept at performing experiments in cutting edge areas of emerging biotechnology
6	The engineer and society	Conduct themselves to uphold the professional and social obligations
7	Environment and sustainability	Design the system with environmental consciousness and sustainable development.

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8	Ethics	Interact with industry, business and society in a professional and ethical manner They will demonstrate the ability and requirements to sense the needs of the nation and their role in nation building.
9	Individual and team work	Function in a multidisciplinary team
10	Communication	The student is trained in both verbal and written communication in English.
11	Project management and finance	Having undergone a project the student is capable of designing, performing and interpreting the results of their experiment. Thereby implement cost effective and improved system
12	Life-long learning	Graduate will develop confidence for self education and ability for life-long learning.

3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

Programme Educational Objectives	Programme Outcomes (PO)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1.	✔	✔	✔	✔								
2.	✔	✔										
3.		✔	✔	✔		✔				✔	✔	✔
4.								✔	✔		✔	
5.							✔	✔		✔		
6.	✔	✔	✔	✔					✔			
7.								✔		✔	✔	✔
8.					✔	✔	✔	✔		✔	✔	✔

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4. MAPPING OF COURSE OUTCOMES AND PROGRAMME OUTCOMES

		Course Name	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
YEAR 1	SEM ESTERI	Tissue Engineering and Regenerative Medicine	3	1	2	2	3	-	2	2	2	-	2	-
		Metabolic engineering	3	3	3	3	3	3	2	2	1	-	-	3
		Immunotechnology	1	2	2	3	2	2	2	1	1	-	1	3
		Professional Elective 1												
		Professional Elective 2												
		Research Methodology and IPR												
		Audit Course - I												
		Professional Elective 3												
		Immunotechnology Laboratory	1	2	2	3	2	2	2	1	1	-	1	3
	SEMESTER II	Advances in Animal Biotechnology	2	2	2	1	2	-	1	1	1	-	-	1
		Applied genomics and proteomics	2	2	-	2	2	2		2		1	1	2
		Computational Biology	3	3	3	2	3	–	–	–	–	–	–	–
		Audit Course - II												
		Professional Elective 4												
		Professional Elective 5												
		Open Elective												
		Mini project with seminar												
		Computational Biology Laboratory	2	3	3	2	3	–	–	–	–	–	–	–
YEAR 2	SEMESTER III	Integrated bioprocess development laboratory	3	3	3	3	3	3	3	2	1	-	-	2
		Sophisticated Analytical Techniques in Biotechnology laboratory	3	3	3	2	3	3	2	2	1	-	-	1
		Metabolic engineering laboratory	3	3	3	3	3	3	3	2	2	1	-	-
		Project Phase – I	2	3	2	2	2	1	-	2	2	2	1	1
	SEMESTER IV	Project Phase – II	2	3	2	2	2	1	-	2	2	2	1	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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UNIVERSITY DEPARTMENTS

M. TECH. BIOTECHNOLOGY

REGULATIONS – 2019

CHOICE BASED CREDIT SYSTEM CURRICULUM AND

SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

S.NO.	CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIOD	CREDITS
				L	T	P		
THEORY								
1	BT5101	Tissue Engineering and Regenerative Medicine	PCC	3	0	0	3	3
2	BT5153	Metabolic Engineering	PCC	3	0	0	3	3
3	BT5102	Immunotechnology	PCC	3	0	0	3	3
4		Professional Elective I	PEC	3	0	0	3	3
5		Professional Elective II	PEC	3	0	0	3	3
6		Professional Elective III	PEC	3	0	0	3	3
7	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
8		Audit Course – I*	AC	2	0	0	2	0
PRACTICALS								
9	BT5111	Immunotechnology Laboratory	PCC	0	0	6	6	3
			TOTAL	**22**	**0**	**6**	**28**	**23**

*Audit Course is Optional

SEMESTER II

S.NO	CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIOD	CREDITS
				L	T	P		
THEORY								
1	BT5251	Advances in Animal Biotechnology	PCC	3	0	0	3	3
2	BT5252	Applied genomics and proteomics	PCC	3	0	0	3	3
3	BT5201	Computational Biology	PCC	3	0	0	3	3
4		Open Elective	OEC	3	0	0	3	3
5		Professional Elective IV	PEC	3	0	0	3	3
6		Professional Elective V	PEC	3	0	0	3	3
7		Audit Course – II*	AC	2	0	0	2	0
PRACTICALS								
8	BT5211	Computational Biology Laboratory	PCC	0	0	4	4	2
9	BT5212	Mini project with seminar	EEC	0	1	2	3	2
			TOTAL	**20**	**1**	**6**	**27**	**22**

*Audit Course is Optional

SEMESTER III

S.NO	CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIOD	CREDITS
				L	T	P		
PRACTICALS								
1	BT5311	Integrated bioprocess development laboratory	PCC	0	0	6	6	3
2	BT5361	Sophisticated Analytical Techniques in Biotechnology laboratory	PCC	0	0	6	6	3
3	BT5312	Metabolic Engineering Laboratory	PCC	0	0	6	6	3
4	BT5313	Project Phase –I	EEC	0	0	12	12	6
			TOTAL	**0**	**0**	**30**	**30**	**15**

SEMESTER IV

S.NO	CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIOD	CREDITS
				L	T	P		
PRACTICALS								
1	BT5411	Project Phase – II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

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TOTAL NO OF CREDITS: 72

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PROFESSSIONAL CORE (PCC)

Sl. No.	CODE NO	COURSE TITLE	L	T	P	CREDITS	SEMESTER
1.	BT5101	Tissue Engineering and Regenerative Medicine	3	0	0	3	I
2.	BT5153	Metabolic engineering	3	0	0	3	I
3.	BT5102	Immunotechnology	3	0	0	3	I
4.	BT5111	Immunotechnology Laboratory	0	0	6	3	I
5.	BT5251	Advances in Animal Biotechnology	3	0	0	3	II
6.	BT5252	Applied genomics and proteomics	3	0	0	3	II
7.	BT5201	Computational Biology	3	0	0	3	II
8.	BT5211	Computational Biology Laboratory	0	0	4	2	II
9	BT5311	Integrated bioprocess development laboratory	0	0	6	3	III
10	BT5361	Sophisticated Analytical Techniques in Biotechnology laboratory	0	0	6	3	III
11	BT5312	Metabolic engineering laboratory	0	0	6	3	III

PROFESSIONAL ELECTIVES (PEC)

S. No.	COURSE CODE	COURSE TITLE	CATE GORY	TOTAL CONTACT PERIODS	L	T	P	CREDITS
1	BT5001	Environmental Biotechnology	PEC	3	3	0	0	3
2	BT5072	Enzyme engineering and technology	PEC	3	3	0	0	3
3	BT5073	Nanobiotechnology	PEC	3	3	0	0	3
4	BT5002	Biosafety and Bioethics	PEC	3	3	0	0	3
5	BT5003	Biomedical devices	PEC	3	3	0	0	3
6	BT5004	Bioprocess Modeling and Simulation	PEC	4	2	0	2	3
7.	BT5005	Molecular diagnostics	PEC	3	3	0	0	3
8.	BT5071	Applied Statistics for Biologists	PEC	3	2	1	0	3
9.	BT5006	Biofuels and Platform Chemicals	PEC	3	3	0	0	3
10.	BT5007	Food Processing and Biotechnology	PEC	3	3	0	0	3
11.	BT5008	Bioseparation Technology	PEC	3	3	0	0	3
12.	BT5009	Pharmaceutical Biotechnology	PEC	3	3	0	0	3
13.	BT5010	Techniques in Molecular Biology and Genetic Engineering	PEC	3	3	0	0	3
14.	BT5011	Plant Genetic Engineering and Biotechnology	PEC	4	2	0	2	3
15.	BT5012	Molecular Pathogenesis of infectious diseases	PEC	3	3	0	0	3
16.	BT5013	Computational Fluid Dynamics	PEC	3	3	0	0	3
17.	BT5014	Computational Techniques in Bioprocess	PEC	3	2	0	2	3
18.	BT5015	Plant Design and Practice	PEC	3	3	0	0	3
19.	BT5016	GMP and validation in Bioprocess industries	PEC	3	3	0	0	3
20	BT5017	Human Heredity and Genetics	PEC	3	3	0	0	3
21	BT5018	Advances in Bioprocess Technology	PEC	3	3	0	0	3
22	BC5071	Structural Biology	PEC	2	2	0	2	3
23	BP5072	Biogenerics and Biopharmaceuticals	PEC	3	3	0	0	3
24	BP5073	Clinical Trials and bioethics	PEC	3	3	0	0	3
25	BP5074	Molecular Medicine and Mechanism	PEC	3	3	0	0	3
26	BC5072	Synthetic Biology	PEC	3	3	0	0	3

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RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. No.	CODE NO.	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1	RM5151	Research Methodology and IPR	2	0	0	2	1

OPEN ELECTIVE COURSES [OEC]*

*(Out of 6 Courses one Course must be selected)

SI.NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

S. NO.	COURSE CODE	COURSETITLE	PERIODSPERWEEK			CREDITS	SEMESTER
			Lectur	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	
					Total Credits	**0**	

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EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	Code No.	Course name	L	T	P	Credits	semester
1	BT5212	Mini project with seminar	0	1	2	2	II
2	BT5313	Project Work Phase – I	12	0	0	6	III
3	BT5411	Project Work Phase – II	24	0	0	12	IV

SUMMARY

CATE GORY	SEM 1	SEM 2	SEM 3	SEM 4	Total
PCC	12	11	9	-	32
PEC	9	6	-	-	15
RMC	2	-	-	-	2
AC (Non Credit)	-	-	-	-	-
OEC	-	3	-	-	3
EEC	-	2	6	12	20
Total Credit	23	22	15	12	**72**

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SYLLABI

SEMESTER I

BT5101 TISSUE ENGINEERING AND REGENERATIVE MEDICINE L T P C
3 0 0 3

OBJECTIVES

The course aims to

- give advanced theoretical knowledge on tissue engineering,
- give basic knowledge about stem cells
- make the students understand the clinical applications

UNIT I INTRODUCTION 9

Introduction to tissue engineering: Basic definition; current scope of development; use in therapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, number viability, motility and functions. Measurement of tissue appearance, cellular component, ECM component, mechanical measurements and physical properties.

UNIT II TISSUE ARCHITECTURE 9

Tissue types and Tissue components, Tissue repair, Basic wound healing events, Applications of growth factors: Role of VEGF. Angiogenesis, Basic properties, Cell-Matrix & Cell-Cell Interactions, Control of cell migration in tissue engineering.

UNIT III BIOMATERIALS 9

Biomaterials: Properties of Biomaterials ,Surface, bulk, mechanical and biological properties. Scaffolds & tissue engineering, Types of Biomaterials, biological and synthetic materials, Biopolymers, Applications of biomaterials, Modifications of Biomaterials, Role of Nanotechnology. 3D Bio-printing , Principle, creating bioink, printing process, multidisciplinary nature of clinical 3D bioprinting, advantages and limitations of 3D modeling, software for bio-printing.

UNIT IV BASIC BIOLOGY OF STEM CELLS 9

Stem Cells : Introduction, Types & sources of stem cell with characteristics :hematopoietic differentiation pathway, Potency and plasticity of stem cells, sources, embryonic stem cells, hematopoietic and mesenchymal stem cells, Stem Cell markers, FACS analysis, Differentiation, Stem cell systems- Liver, neuronal stem cells, cancer stem cells, induced pleuripotent stem cells.

UNIT V CLINICAL APPLICATIONS 9

Stem cell therapy, Molecular therapy, In vitro organogenesis, Neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopedic applications, Stem cells and Gene therapy, Physiological models, tissue engineering therapies, product characterization, components, safety, efficacy. Preservation – freezing and drying. Patent protection and regulation of of tissue-engineered products, ethical issues.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1 understand tissue engineering in biomedical applications
CO2 elaborate tissue microenvironment and its major modulators
CO3 using biomaterials and its futuristic applications including 3D printing technology.
CO4 apply stem cell technology in tissue engineering
CO5 perform tissue engineering in clinical challenges

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REFERENCES

1. Principles of Tissue Engineering, 4th Edition, Editors: Robert Lanza Robert Langer Joseph Vacanti eBook, Academic Press, 2013
2. Introduction to Tissue Engineering: Applications and Challenges : Ravi Birla, (IEEE Press Series on Biomedical Engineering) 1st Edition, Wiley-Blackwell; 1 edition, 2014

Course Articulation Matrix

Course Outcomes Statement		Program Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO 1	Understand the tissue engineering in biomedical applications with basic understanding of cell biology.	3	1	1	-	2	-	-	2	-	-	2	-
CO 2	elaborate tissue microenvironment and its major modulators	3	2	1	-	2	-	-	-	-	-	-	
CO 3	using biomaterials and its futuristic applications including 3D printing technology.	2	1	2	2	3	-	2	-	-	-	-	
CO 4	apply stem cell technology in tissue engineering	2	1	3	1	3	-	2	-	-	-	-	
CO 5	perform tissue engineering in clinical challenges	3	1	3	3	2	-	-	2	2	-	-	-
Overall CO		3	1	3	3	3	-	2	2	2	-	2	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT5153 METABOLIC ENGINEERING L T P C
3 0 0 3

OBJECTIVES

The course aims to

- familiarize the student with quantitative approaches for analyzing cellular metabolism
- make the students aware of the use of theoretical and experimental tools that can give insights into the structure and regulation of metabolic networks.
- identify the optimal strategy for introducing directed genetic changes in the microorganisms with the aim of obtaining better production strains using case studies.

UNIT I METABOLIC FLUX ANALYSIS 9

Introduction to metabolic engineering, comprehensive models of cellular reactions with stoichiometry and reaction rates; metabolic flux analysis of exactly/over/under determined systems. Shadow price, sensitivity analysis.

UNIT II TOOLS FOR EXPERIMENTALLY DETERMINING FLUX THROUGH PATHWAYS 9

Monitoring and measuring the metabolome, Methods for the experimental determination of metabolic fluxes by isotope labeling metabolic fluxes using various separation-analytical techniques. GC-MS for metabolic flux analysis, genome wide technologies: DNA /phenotypic microarrays and proteomics.

UNIT III CONSTRAINT BASED GENOMIC SCALE METABOLIC MODEL 9

Development of Genomic scale metabolic model, *Insilico* Cells:studying genotype-phenotype relationships using constraint-based models, case studies in *E. coli, S.cerevisiae* metabolic network reconstruction methods, optimization of metabolic network, Identification of targets for metabolic engineering; software and databases for genome scale modeling

UNIT IV METABOLIC CONTROL ANALYSIS AND KINETIC MODELING 9

Fundamental of Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients. Multi-substrate enzyme kinetics, engineering multifunctional enzyme systems for optimal conversion, and a multi scale approach for the predictive modeling of metabolic regulation.

UNIT V CASE STUDIES IN METABOLIC ENGINEERING 9

Metabolic engineering examples for bio-fuel, bio-plastic and green chemical synthesis. Study of genome scale model in various systems for the production of green chemicals using software tools. Validation of the model with experimental parameters.

TOTAL :45 PERIODS

OUTCOMES

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

CO1 gain insights of the metabolic flux analysis both theoretically and experimentally
CO2 gain experience in the development of genome scale metabolic modelling
CO3 have a clear understanding on metabolic control analysis
CO4 understand metabolic engineering using real time examples case

REFERENCES

1. Stephanopoulos, G.N. “Metabolic Engineering: Principles and Methodologies”. Academic Press / Elsevier, 1998.
2. Lee, S.Y. and Papoutsakis, E.T. “Metabolic Engineering”. Marcel Dekker, 1998.
3. Nielsen, J. and Villadsen, J. “Bioreaction Engineering Principles”. Springer, 2007.
4. Smolke, Christiana D., “The Metabolic Pathway Engineering Handbook Fundamentals”, CRC Press Taylor & Francis, 1st edition 2010.
5. Voit, E.O. “Computational Analysis of Biochemical Systems : A Practical Guide for
6. Biochemists and Molecular Biologists”. Cambridge University Press, 1st edition 2000.
7. Scheper, T. “Metabolic Engineering” Vol 73 (Advances in Biochemical Engineering
8. Biotechnology) Springer, 2001.
9. 7. Cortassa, S. et al, “ An Introduction to Metabolic and Cellular Engineering”, World Scientific Publishing, 2012.
10. Kholodenko, Boris N and H. V. Westerhoff “Metabolic Engineering in the Post Genomic Era”, Horizon Bioscience, 1st edition, 2004

Course Articulation Matrix

Course outcome Statements		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	gain insights of the metabolic flux analysis both theoretically and experimentally	3	3	3	3	3	3	2	2	1	-	-	3
CO2	gain experience in the development of genome scale metabolic modeling	2	3	3	2	-	-	-	-	-	-	-	3
CO3	have a clear understanding on metabolic control analysis	3	2	3	3	-	2	3	-	-	-	-	3
CO4	understand metabolic engineering using real time examples case	3	3	3	3	3	3	2	2	1	-	-	3
Overall CO		3	3	3	3	3	3	2	2	1	-	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5102 **IMMUNOTECHNOLOGY** **LT PC**
3 0 0 3

OBJECTIVES

The course aims to

- understand the applications of immunology for the development of diagnostics
- understand the basic principles of vaccine development
- make use of the knowledge of immunotechnology for clinical applications and also become aware of the regulatory issues.

UNIT I INTRODUCTION 12

Review on Cells of the immune system and their development; primary and secondary lymphoid organs; humoral immune response; cell mediated immune responses; complement, classification of T cells and B cells, cell markers.

UNIT II ANTIBODIES 10

Development of Monoclonal antibodies, classification and their applications; ELISA – types; IFT (direct and indirect) Agglutination tests; Antigen detection assay; Plaque Forming Cell Assay, Development of rapid immunodiagnostics - Immuno- lateral flow / flow through assays. diagnosis of immediate and delayed hypersensitivity, anaphylactic reaction, total Ig and antigen specific IgE antibody assay, assay for haemolytic diseases, assay for immune complex, skin tests for DTH response

UNIT III DEVELOPMENT OF IMMUNOASSAYS 12

PBMC separation from the blood; identification of lymphocytes based on CD markers; FACS; Lympho proliferation assay; Mixed lymphocyte reaction; Cr51 release assay; macrophage cultures; cytokine bioassays- IL2, gamma IFN, TNF alpha.; HLA typing.

UNIT IV VACCINE TECHNOLOGY 6

Principles of vaccine development, types; Development of vaccines for bacterial, viral and parasitic diseases, Regulatory requirements for vaccine development and testing, ethical issues, protein based vaccines; sub-unit vaccines, DNA vaccines; Plant based vaccines; recombinant antigens as vaccines; reverse vaccinology, cancer vaccines, customized therapeutic cancer vaccines, (scFv) antibodies and molecular evolution of scFv for enhanced sensitivity and specificity,

UNIT V DEVELOPMENT OF IMMUNOTHERAPEUTICS 5

Development of effective immuno drug targets for infectious diseases, engineered antibodies; catalytic antibodies; idiotypic antibodies; dendritic cells based immunotherapy, combinatorial libraries for antibody isolation, CAR T-cell therapy, Immune check point inhibitors.

TOTAL: 45 PERIODS

OUTCOMES

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

CO 1 have an understanding of the science of immunology
CO2 apply the technology for the development of immunotherapeutics and diagnosis
CO 3 become an entrepreneur in the field of immunotechnology

REFERENCES

1. Roitt, Ivan. Essential Immunology 9th Edition., Blackwell Scientific, 13th edition, 2017
2. Roitt I., Brostoff J. and Male D. Immunology, 6th ed. Mosby, 2001
3. Goldsby , R.A., Kindt, T.J., Osbome, B.A. and Kerby J. Immunology, 6th ed., W.H. Freeman, 2006
4. Janeway's Immunobiology, Ninth Edition, Kenneth M. Murphy, Casey Weaver, 2017
5. Roitt's Essential Immunology, 13th Edition, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, 2017
6. Lippincott Illustrated Reviews: Immunology, 2nd ed., 2012

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Course Articulation Matrix

Course Outcome Statements		Programme Outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	have an understanding of the science of immunology	3	2	1	2	1	2	1	-	-	-	-	2
CO2	apply the technology for the development of immunotherapeutics and diagnosis	1	3	3	3	3	1	1	1	-	-	1	3
CO3	become an entrepreneur in the field of immunotechnology	-	2	3	3	2	3	3	3	3	2	2	2
Overall CO		1	2	2	3	2	2	2	1	1	-	1	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

RM5151 **RESEARCH METHODOLOGY AND IPR** **L T P C**
2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION **6**

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 II LITERATURE REVIEW **6**

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICALWRITING /PRESENTATION **6**

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 IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) **6**

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.

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UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

COURCE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

REFERENCES:

1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

BT5111 IMMUNOTECHNOLOGY LABORATORY LT P C
0 0 6 3

OBJECTIVES

The course aims to

- make the students skilled in the fundamental techniques in immunology
- equip them the latest techniques required for developing skills in Immunotechnology

LIST OF EXPERIMENTS

1. Ethics, selection and handling of animals for immunological experiments (Eg. Mice, Rats, Rabbits).
2. Preparation of antigens for immunisation and Routes of immunisation (Eg. Intra-peritonial, Sub-cutaneous, Intra-muscular,Intra-nasal).
3. Methods of bleeding (Eg. Tail bleeding, Intravenous, intraorbital)
4. Collection of serum, storage and purification of total IgG (salt precipitation; Protein A).
5. Evaluation of Antibody titre by direct ELISA.
6. Evaluation of Antigen by Sandwich ELISA.
7. Characterisation of antigens by native, SDS-PAGE.
8. Characterisation of antigens by Immunoblotting.
9. Conjugation of Immunoglobins (Streptavidin/colloidal gold/enzyme conjugation).
10. Methods for prototype development of Immunodiagnostics (Lateral flow or rapid immunoflow-through assays).
11. Identification of leucocytes by Giemsa stain from blood smear.
12. Outline the process of monoclonal antibody production (batch demonstrations)
13. Screening of lymphocytes by FACS
14. Separation of mononuclear cells by Ficoll-Hypaque.
15. Separation of spleenocytes and proliferation against mitogens (MTT assay) (abattoir specimens or voluntary specimens from research projects under CPCSEA guidelines and the procedure will be demonstrated).

TOTAL :90 PERIODS

OUTCOMES

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

CO1 have an understanding of the experimental aspects of immunotechnology
CO2 acquire basics skills for the development of immunotherapeutics and diagnosis
CO3 have knowledge in designing immunotech experiments and interpretation

REFERENCES

1. Antibodies: A Laboratory Manual, Ed Harlow, David P Lane, Cold Spring Harbor Laboratory Press, 2nd Edition, 1998 and updated editions
2. Molecular cloning : A laboratory manual / Joseph Sambrook, David W. Russell. 3rd ed. Cold Spring Harbor, N.Y. : Cold Spring Harbor Laboratory, 2001
3. Current protocols in immunology / editorial board John E. Coligan .et al,. 2003, New York : Wiley Interscience, 2003.

Course Articulation Matrix

Course Outcome Statement		Programme Outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	have an understanding of the experimental aspects of immunotechnology	3	2	1	2	1	2	1	-	-	-	-	2
CO2	acquire basics skills for the development of immunotherapeutics and diagnosis	1	3	3	3	3	1	1	1	-	-	1	3
CO3	have knowledge designing experiments and interpreting results in immunotechnology	-	2	3	3	2	3	3	3	3	2	2	2
Overall CO		1	2	2	3	2	2	2	1	1	-	1	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

SEMESTER II

BT5251 ADVANCES IN ANIMAL BIOTECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- make the students appreciate the fine aspects of animal biotechnology
- know the principles of utilizing recombinant cells/ transgenic animals for clinical/ industrial applications

. **UNIT I INTRODUCTION 4**

Scope of Animal Biotechnology, Animal Biotechnology for production of regulatory proteins, blood products, vaccines, hormones and other therapeutic proteins.

UNIT II MOLECULAR BIOLOGY 9

Biology of animal viral vectors- SV40, adeno virus, retrovirus, vaccinia virus, herpes virus, adeno associated virus and baculo virus.

UNIT III CELL CULTURE TECHNOLOGY 11

Culturing of cells, primary and secondary cell lines, Cell culture-Scaling up of animal cell culture-monolayer culture, suspension culture; Various bio-reactors used for animal cell culture-Roller bottle culture; Bioreactor process control, stirred animal cell culture, Air-lift fermentor, Chemostat/Turbidostat; High technology vaccines: Hybridoma technology; Cell lines and their applications

UNIT IV GENETIC ENGINEERING 11

Gene therapy-prospects and problems; Knockout mice and mice model for human genetic disorder; Baculo virus in biocontrol; Enzymes technology, Somatic manipulation of DNA, Nucleic acid hybridization and probes in diagnosis- preparation of probes, evaluation and applications.

UNIT V APPLICATIONS 10

Rumen manipulation- probiotics embryo transfer technology, invitro fertilization, transgenesis- methods of transferring genes into animal oocytes, eggs, embryos and specific tissues by physical, chemical and biological methods; Biopharming - Transgenic animals (Mice, Cows, Pigs, Sheep, Goat, Birds and Insects); Artificial insemination and embryo transfer, cryopreservation and CRISPR.

TOTAL :45 PERIODS

OUTCOMES:

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

CO1 gain insights and have the scope of animal biotechnology

CO2 gain experience in the development of molecular tools for viral vector based gene delivery

CO3 have a clear understanding on scaling up animal cell culture in industry

CO4 understand the scope and uses of genetic engineering in animal biotechnology

CO5 understand the application of animal biotechnology knowledge in live stock industry.

REFERENCES

1. Watson, J.D., Gilman, M., WitowskiJ. and Zoller, M. Recombinant DNA, 3rd ed., Scientific American Books, 2007
2. Glick, B.R. and Pasternack, J.J. Molecular Biotechnology, 3rd ed., ASM Press, 2003
3. Lewin, B. Genes VIII , Pearson Prentice Hall, 2004
4. Davis J.M. Basic Cell Culture: A Practical Approach, IRL Press, 2nd ed., 2002
5. Freshney R.I. Animal Cell Culture- a practical approach, 6th ed., 2010

Course Articulation Matrix

Course outcome Statement		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	gain insights and have the scope of animal biotechnology – Indian perspective	3	3	3	3	3	3	2	2	1	-	-	3
CO2	gain experience in the development of molecular biology tools for viral vector based gene delivery	2	3	3	2	-	-	-	-	-	-	-	3
CO3	have a clear understanding on scaling up animal cell culture in industry	3	2	3	3	-	2	3	-	-	-	-	3
CO4	understand the scope and uses of genetic engineering in animal biotechnology	3	3	3	3	3	3	2	2	1	-	-	3
CO5	understand the application of animal biotechnology knowledge in live stock industry.	3	2	2	2	3	2	2	2	2	-	-	2
Overall CO		2	2	2	1	2	-	1	1	1	-	-	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT5252 APPLIED GENOMICS AND PROTEOMICS LT PC
3 0 0 3

OBJECTIVES

The course aims to

- provide advanced theoretical knowledge on the organization and function of genomes
- understand the principles of functional genomic analyses
- have knowledge on the advanced methods and approaches in proteomics.

UNIT I STRUCTURE OF GENOMES, MAPPING AND SEQUENCING 9

Organization and structure of genomes in prokaryotes, eukaryotes, and organelles (chloroplast, mitochondrion); Genome mapping methods (genetic and physical);RAPD, RFLP, SNP analyses; Fluorescence In-Situ Hybridization (FISH) techniques; Advances in gene finding and functional prediction; Chain termination and chemical degradation sequencing methods.

UNIT II LARGE SCALE GENOMICS/ FUNCTIONAL GENOMICS ANALYSES 9

Genome-wide association (GWA) analysis; Comparative Genomic Hybridization (CGH); Massively parallel Signature Sequencing(MPSS); Whole genome shot-gun sequencing and its applications. Introduction of Next Generation Sequencing (NGS).

UNIT III TRANSCRIPTOMICS ANALYSES 9

Gene expression analysis by cDNA and oligonucleotide arrays; Micro array experimental analysis and data analysis. Methylome analysis using microarray; ChIP-on-Chip analysis. Bioinformatic analysis of large-scale microarray data for comparative transcriptomics.

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UNIT IV SEPARATION AND PROCESSING OF PROTEINS FOR PROTEOMICS 9

Over-view of strategies used for the identification and analysis of proteins; Protein extraction from biological samples (Mammalian Tissues, Yeast, Bacteria, and Plant Tissues); 2-DE of proteins for proteome analysis; Liquid chromatography separations in proteomics (Affinity, Ion Exchange, Reversed-phase, and size exclusion); Enzymatic cleavage of proteins. Analysis of complex protein mixtures using Nano-liquid chromatography (Nano-LC) coupled to Mass-spectrometry analysis.

UNIT V MASS SPECTROMETRY AND COMPARATIVE PROTEOMICS 9

Common ionization methods for peptide/protein analysis; Introduction to Mass spectrometers; MALDI-TOF and LC-MS analyses; Comparative proteomics based on global in-vitro and in-vivo labeling of proteins/peptides followed by Mass-spectrometry. Analysis of posttranslational modification (PTM) of proteins; Characterization of protein interactions using yeast two-hybrid system and Protein microarrays; Proteomics informatics and analysis of protein functions.

TOTAL:45 PERIODS

OUTCOMES:

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

CO1 acquire advanced theoretical knowledge on the organization and function of genomes
CO2 perform functional genomic analyses
CO3 apply advanced methods and approaches in proteomics

REFERENCES

1. S.P. Hunt and F. J. Livesey, (2000) Functional Genomics, Oxford University press
2. N. K. Spur, B. D. Young, and S. P. Bryant (1998) ICRF Handbook of Genome Analysis Volume 1 & 2, Black well publishers
3. G. Gibson and S. V. Muse, 3rd ed., (2009) A primer of Genome Science, Sinauer Associates, Inc. Publishers
4. R. J. Reece (2004) Analysis of Genes and Genomes, John Wiley & Sons Ltd
5. Rinaldis E. D. and Lahm A (2007)DNA Microarrays. Horizon bioscience.
6. Simpson R. J."Proteins and Proteomics - A Laboratory Manual".Cold Spring Harbour Laboratory Press, 2002.
7. Twyman R. M. "Principles of Proteomics". Taylor & Francis. 2004
8. O'Connor C. D. and Hames B. D. "Proteomics". Scion, 2008.
9. Schena M. "Protein Microarrays". Jones and Bartlett, 2005.
10. Smejkal G. B. and Lazarev A. V. "Separation methods in Proteomics". CRC Press, 2006.

Course Articulation Matrix

Course Outcome Statement		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	acquire advanced theoretical knowledge on the organization and function of genomes	2	-	-	-	2	2	-	1	-	1	1	2
CO2	perform functional genomic analyses	2	2	-	2	-	2	-	2	-	1	1	2
CO3	apply advanced methods and approaches in proteomics	3	3	-	2	2	2	-	2	-	1	1	2
Overall CO		2	2	-	2	2	2	-	2	-	1	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5201 **COMPUTATIONAL BIOLOGY** **LT PC**
3 0 0 3

OBJECTIVES

The course aims to

- introduce the student to biological data and sequence analysis, phylogenetics and next generation sequencing data analysis
- get familiarized with protein three dimensional structure, modeling, docking and molecular dynamics simulations
- Understand basics concepts in Machine learning, Systems Biology approaches and informatics techniques for protein identification

UNIT I INTRODUCTION TO COMPUTATIONAL BIOLOGY AND SEQUENCE ANALYSIS 9

Molecular sequences, Genome sequencing: pipeline and data, Biological databases, Sequence Alignment, Local and Global Alignment, Needleman Wunsch Algorithm, Smith Waterman Algorithm, BLAST family of programs, Functional Annotation, Progressive and Iterative Methods for Multiple sequence alignment, Applications.

UNIT II BIG DATA IN BIOLOGY NEXT GENERATION SEQUENCING DATA AND ANALYSIS 9

Introduction to Big Data in Biology, GEO and SRA databases, Exome Sequencing, Single cell sequencing, Next Generation Sequence Analysis, RNA-Seq Data and Analysis, Methylome Sequence Data and Analysis, miRNA sequence data and analysis, CHiP seq data and analysis

UNIT III PHYLOGENETICS AND MODELS OF EVOLUTION 7

Introduction to Phylogenetics, Jukes Cantor and Kimura Models of Evolution, Distance and Character based methods for phylogenetic tree construction: Unweighted Pair Group Method of Arithmetic Averages, Neighbour joining Trees, Maximum Likelihood Trees, Ultrametric and Min ultrametric trees, Parsimonous trees, Additive trees, Assessing the reliability of phylogenetic trees-Bootstrapping.

UNIT IV PROTEIN STRUCTURE, MODELLING AND SIMULATIONS 9

Protein Structure Basics, Visualization, Prediction of Secondary Structure and Tertiary Structure, Homology Modeling, Protein Protein Interactions, Molecular Docking principles and applications, Molecular dynamics simulations.

UNIT V MACHINE LEARNING, SYSTEMS BIOLOGY AND OTHER ADVANCED TOPICS 11

Machine learning techniques: Artificial Neural Networks Applications in Protein secondary structure prediction, Hidden Markov Models for protein and gene families, Introduction to Systems Biology, Biological networks : Protein interaction and Gene regulatory networks and network motifs Single Input Module, Dense Overlapping Regulon and Feed Forward Loops, Microarrays and Clustering techniques for microarray data analysis, Informatics techniques for analysis of Mass spectrometry data : protein identification.

TOTAL:45 PERIODS

OUTCOMES

At the end of the course the student will be able to

CO1 understand concepts in biological sequence analysis, next generation sequencing data analysis

CO2 understand the utility of molecular docking and simulations and analyze the results

CO3 understand machine learning techniques, networks in Systems biology, microarray data analysis and interpretation of results

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REFERENCES

1. Dan Gusfield, Algorithms on Strings Trees and Sequences, Cambridge University Press, 1st ed., 1997.
2. David W. Mount Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press, 2nd ed., 2004
3. Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, 2014
4. Andrew R. Leach, Molecular Modeling Principles And Applications, Prentice Hall, 2009
5. Baldi, P., Brunak, S. Bioinformatics: The Machine Learning Approach, East West Press, 2nd 2001
6. Durbin, R. Eddy S., Krogh A., Mitchison G. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, Cambridge University Press, 1998
7. Proteomics from protein sequence to function: Edited by S.R.Pennington and M.J.Dunn,Taylor and Francis Group, 2001
8. Big Data Analysis for Bioinformatics and Biomedical Discoveries Edited by Shui Qing Ye, CRC Press, Taylor and Francis Group, 2015
9. An Introduction to System Biology Design Principles Of Biological Circuits by Uri Alon, 2006

Course Articulation Matrix

Course Outcomes Statement		Program Outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	understand concepts in biological sequence analysis, next generation sequencing data analysis	3	3	3	2	3	–	–	–	–	–	–	–
CO2	understand the utility of molecular docking and simulations and analyze the results	3	3	3	2	3	–	–	–	–	–	–	–
CO3	understand machine learning techniques, networks in Systems biology, microarray data analysis and interpretation of results	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5211 COMPUTATIONAL BIOLOGY LABORATORY LT PC
0 0 4 2

OBJECTIVES

The course aims to

- introduce the student to biological databases and bioinformatics tools
- develop skills in protein structural studies including docking and molecular dynamics simulations
- familiarize with next generation sequencing data and analysis

LIST OF EXPERIMENTS

1. Introduction to Multiuser Operating System Linux
2. Biological databases Data Retrieval
3. Sequence Analysis- Local and Global alignment Tools
4. HMMER - Building Hidden Markov Models for Protein And Gene Families
5. Protein Structure: Data, Visualization, Alignment, Pocket detection, Homology Modeling
6. Molecular Docking : Protein-Protein and Protein Small molecule/drug
7. Molecular Dynamics Simulation: GROMACS
8. Building and Visualizing Protein Interaction Networks
9. Proteomics Tools at ExPasy Identifying proteins from mass spectrometry data
10. Next Generation Sequencing Data resources
11. Bioconductor package for RNA-Seq Data Analysis: Differential Gene Expression Analysis, ncRNAs miRNA target prediction

TOTAL :60 PERIODS

OUTCOMES:

At the end of the course the student will be able to

CO1 retrieve biological data from diverse sources, perform sequence and structure related analysis

CO2 run molecular docking and molecular dynamics simulations and interpret results

CO3 perform basic Next Generation Sequencing data analysis

REFERENCES

1. Dan Gusfield. Algorithms on Strings Trees and Sequences, Cambridge University Press, 1997
2. David W. Mount Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press, Second Edition, 2004.
3. Arthur M. Lesk, Introduction to Bioinformatics by Oxford University Press, 2008.
4. Tisdall, James, Beginning PERL for Bioinformatics, O'Reilley Publications, 2001.
5. Andrew R. Leach, Molecular Modeling Principles And Applications, Second Edition, Prentice Hall, 2009

Course Articulation Matrix

Course Outcomes Statement		Program Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	retrieve biological data from diverse sources, perform sequence and structure related analysis	2	3	3	2	3	–	–	–	–	–	–	–
CO2	run molecular docking and molecular dynamics simulations and interpret results	2	3	3	2	3	–	–	–	–	–	–	–
CO3	perform basic Next Generation Sequencing data analysis	2	3	3	2	3	–	–	–	–	–	–	–
Overall CO		2	3	3	2	3	–	–	–	–	–	–	–

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5212 **MINI PROJECT WITH SEMINAR** **L T P C**
0 1 2 2

OBJECTIVES

The course aims to

- encourage the students to get connected with relevant industries/laboratory/research institutes
- acquire knowledge on solving practical problems, gaining work experience and skills
- learn the basics of research methodologies in academic/industrial/research environment

The students individually undergo training in reputed companies/research institutes/ organizations for the specified duration

OUTCOMES:

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

CO 1 learn methods and procedures from industrial/academic/research institute

CO2 gain experience to work as an member in industrial or research team for

CO 3 acquire practical knowledge and enhance skills

Course Articulation Matrix

Course outcome Statements		Programme outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	learn to work in an industrial/academic/research institute	1	3	2	3	3	3	2	3	2	3	2	3
CO2	gain experience to work as an individual as well as a member of a team	1	3	2	3	3	3	2	3	2	3	2	3
CO3	acquire practical knowledge and enhance skills	1	3	2	3	3	3	2	3	2	3	2	3
Overall CO		1	3	2	3	3	3	2	3	2	3	2	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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SEMESTER III

BT5311	**INTEGRATED BIOPROCESS DEVELOPMENT LABORATORY**	**LT PC 0 0 6 3**

OBJECTIVES

The course aims to

- inculcate students on the fundamentals of bioprocessing of products (Eg. industrial enzymes etc.,)
- equip the students with the skills required for the steps involved from basic characterization to commercialization of bioproducts

LIST OF EXPERIMENTS

1. Enzyme kinetics, inhibition, factors affecting reaction pH, temp.
2. Enzyme immobilization studies – Gel entrapment, adsorption and Ion-exchange Immobilisation.
3. Bioprocess media optimization techniques – Plackett burman, Response surface methodology.
4. Batch cultivation – recombinant *E.coli* – growth rate, substrate utilization kinetics, plasmid stability, product analysis after induction, Metabolite analysis by HPLC
5. Fed batch cultivation *E.coli, Pichia pastoris*
6. Continuous cultivation – x - d construction, kinetic parameter evaluation, gas analysis, carbon balancing, Pulse and shift techniques.
7. Bioreactor studies : Sterilization kinetics, kLa determination, residence time distribution, sensors for bioprocess monitoring
8. Animal cell culture production: T-flask, spinner flask, bioreactor
9. Cell separation methods; Centrifugation and microfiltration Cell disruption methods: Chemical lysis and Physical methods Product concentration: Precipitation, ATPS, Ultrafiltration
10. High resolution purification; Ion exchange, affinity and Gel filtration, Freeze drying

TOTAL :90 PERIODS

OUTCOMES

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

CO1 experience enzyme kinetics and immobilized enzyme studies
CO2 get an idea on media formulation and mode of microbial cultivation
CO3 perform bioreactor studies and animal cell cultivation
CO4 gain real time experience in downstream processing techniques

REFERENCES

1. Fundamentals of Modern Bioprocessing, Sarfaraz K. Niazi, Justin L. Brown, 1970, CRC Press (https://doi.org/10.1201/b19598)
2. Bioreactors: Animal Cell Culture Control for Bioprocess Engineering Paperback, 2017, Goutam Saha, Alok Barua, Satyabroto Sinha, CRC Press
3. Protein Purification Handbooks, Amersham Biosciences, 2001

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Course Articulation Matrix

Course Outcome Statement		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	experience enzyme kinetics and immobilized enzyme studies	2	1	1	1	-	-	1	1	-	-	-	1
CO2	get an idea on media formulation and mode of microbial cultivation	3	3	2	3	3	2	2	-	-	-	-	-
CO3	perform bioreactor studies and animal cell cultivation	3	3	3	3	3	3	2	2	1	-	-	3
CO4	gain real time experience in downstream processing techniques	3	3	3	3	3	3	2	2	1	-	-	3
Overall CO		3	3	3	3	3	3	3	2	1	-	-	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT5361 SOPHISTICATED ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY LABORATORY **L T P C**
0 0 6 3

OBJECTIVES

The course aims to

- acquaint students with skills needed for understanding the theory and operation of
- apply the theoretical knowledge of the sophisticated analytical laboratory instruments in biotechnological academic and industrial research.

LIST OF EXPERIMENTS

1. Estimation of DNA/protein concentration by conventional and Nano Drop methods
2. Preparative and qualitative estimation of biomolecules by HPLC analysis
3. Evaluation of proteins by SDS-PAGE and Western blot (Chemiluminescence and Fluorescene detection methods).
4. Evaluation of proteins by 2D Gel electrophoresis (demo)
5. Protein mass determination by MALDI-TOF analysis- demo
6. Determination of pathogens by Mass spectrometry
7. Analysis by Real-time PCR (SYBR green method) with melting curve analysis
8. Determination of protein aggregation by Dynamic Light Scattering (DLS)
9. Evaluation of cells by Confocal microscopy
10. FTIR analysis of biomolecules.
11. GC-MS on small molecule analysis- demo
12. Flow cytometry analysis of cell cycle- demo

TOTAL :90 PERIODS

OUTCOMES:

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

CO1 experience basic and widely used techniques in the analysis of biomolecules
CO2 experience overall techniques associated with proteomics such as protein separation by 2D-gel and characterization using mass spectrometer
CO3 experience fluorescence based real-time PCR, cell/tissue confocal imaging and separation using flow cytometer

Attested

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REFERENCES

1. Simpson R. J."Proteins and Proteomics - A Laboratory Manual".Cold Spring Harbour Laboratory Press, 2002.
2. Twyman R. M. "Principles of Proteomics". Taylor & Francis. 2004
3. O'Connor C. D. and Hames B. D. "Proteomics". Scion, 2008.
4. Schena M. "Protein Microarrays". Jones and Bartlett, 2005.
5. Smejkal G. B. and Lazarev A. V. "Separation methods in Proteomics". CRC Press, 2006.
6. Bioreactors: Animal Cell Culture Control for Bioprocess Engineering Paperback, 2017, Goutam Saha, Alok Barua, Satyabroto Sinha, CRC Press
7. Protein Purification Handbooks, Amersham Biosciences, 2001

Course Articulation Matrix

Course Outcome Statement		**Programme Outcomes (PO)**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	experience basic and widely used techniques in the analysis of biomolecules	3	3	2	3	3	2	2	-	-	-	-	-
CO2	experience overall techniques associated with proteomics such as protein separation by 2D-gel and characterization using mass spectrometer	3	3	2	3	3	2	2	-	-	-	-	-
CO3	experience fluorescence based real-time PCR, cell/tissue confocal imaging and separation using flow cytometer	2	3	3	2	2	3	3	3	1	-	-	2
Overall CO		3	3	3	2	3	3	2	2	1	-	-	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

Attested

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BT5312 METABOLIC ENGINEERING LABORATORY LT PC
0 0 6 3

OBJECTIVES

The course aims to

- equip the students on the fundamentals of various molecular techniques
- apply the fundamental techniques for metabolic engineering of microbes.

LIST OF EXPERIMENTS

1. Cloning of multiple gene
2. Knocking out of gene
3. Gene integration in chromosome
4. Chemostat cultivation for carrying out metabolic flux analysis
5. Simulation experiment using genome scale in the metabolic model of E.coli
6. Metabolic control analysis by using cell free system.
7. Perturbation analysis by using cell free system.
8. Anaerobic batch experiment to carry out carbon balancing
9. Kinetic model development in COPASI.
10. Optimization of gene expression using algorithm.
11. Southern hybridization experiment Gene editing using CRISPR/Cas9
12. Determination of metabolite functions and cellular bioenergetics by (Seahorse analysis)

TOTAL : 90 PERIODS

OUTCOMES:

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

CO1 gain insights of the metabolic flux analysis both theoretically and experimentally
CO2 gain experience in the development of genome scale metabolic modelling
CO3 have a clear understanding on metabolic control analysis
CO4 understand metabolic engineering using real time examples case

REFERENCES

1. Stephanopoulos, G.N. “Metabolic Engineering: Principles and Methodologies”. Academic Press / Elsevier, 1998.
2. Lee, S.Y. and Papoutsakis, E.T. “Metabolic Engineering”. Marcel Dekker, 1998.
3. Nielsen, J. and Villadsen, J. “Bioreaction Engineering Principles”. Springer, 2007.
4. Smolke, Christiana D., “The Metabolic Pathway Engineering Handbook Fundamentals”, CRC Press Taylor & Francis, 2010.

Course Articulation Matrix

Course Outcome Statement		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	gain insights of the metabolic flux analysis both theoretically and experimentally	3	3	3	3	3	3	2	2	1	-	-	3
CO2	gain experience in the development of genome scale metabolic modelling	2	3	3	2	-	-	-	-	-	-	-	3
CO3	have a clear understanding on metabolic control analysis	3	2	3	3	-	2	3	-	-	-	-	3
CO4	understand metabolic engineering using real time examples case	3	3	3	3	3	3	2	2	1	-	-	3
Overall CO			3	3	3	3	3	3	2	2	1	-	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5313 **PROJECT PHASE I** **L T P C**
0 0 12 6

OBJECTIVES

The course aims to

- make the students identify a problem/process relevant to their field of interest that can be carried out
- make them equipped to search databases and journals to collect relevant data and identify a solution
- plan, learn and perform experiments to verify the solution

OUTCOMES:

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

CO 1 identify the field of interest towards research/industrial problems

CO 2 equip the students to search and think about logical solutions

Course Articulation Matrix

Course outcome Statements		Programme outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	identify the field of interest towards research/industrial problems	2	3	2	2	1	2	-	2	2	1	1	2
CO2	equip the students to search and think about logical solutions	2	3	2	2	1	2	-	2	2	1	1	2
		2	3	2	2	2	1	-	2	2	2	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

SEMESTER IV

BT5411 **PROJECT PHASE II** **L T P C**
0 0 24 12

OBJECTIVES

The course aims to

- train students to analyze a problem/ think innovatively to develop new methods/product /process
- make them understand how to find solutions/ create products economically and in an environmentally sustainable way
- enable them to acquire technical and experimental skills to validate the solution, analyze the results and communicate
- enable them to effectively think about strategies to commercialize the product .

COURSE OUTCOMES

At the end of the project the student will be able to

CO 1 formulate and analyze problems for developing new methods/solutions/processes.

CO2 plan experiments to find solutions in a logical manner/ work out sustainability

CO 3 analyze the results, interpret and communicate/strategies for commercialization

Course Articulation Matrix

Course outcomes Statement		**Programme outcomes (PO)**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	formulate and analyze a problem/ create a new product/process	1	3	2	2	2	1	-	2	2	2	1	1
CO2	plan experiments to find solutions in a logical manner/ work out sustainability	2	3	2	2	2	1	-	2	2	2	1	1
CO3	analyze the results, interpret and communicate/strategies for commercialization	2	3	2	2	2	1	-	2	2	2	1	1
Overall CO		2	3	2	2	2	1	-	2	2	2	1	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

ELECTIVES

BT5001 ENVIRONMENTAL BIOTECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- teach students the scientific and engineering principles to treat and minimize the global environmental problems.
- substitute the conventional treatment methods with modern biotechnology approaches.
- implement the technologies effectively to evade the environmental issues.

UNIT I FUNDAMENTAL OF ENVIRONMENTAL BIOTECHNOLOGY 7

Microbial flora of soil, Ecological adaptations, Interactions among soil microorganisms, biogeochemical role of soil microorganisms. Biodegradation, Microbiology of degradation and its mechanism, Bioaugmentation, Biosorption, Bioleaching, Bioremediation- Types of Bioremediation, Bioreactors for Bioremediation, Metabolic pathways for Biodegradation for specific organic pollutants.

UNIT II POLLUTION AND CONTROL 11

Pollution- Sources of pollutants for Air, Water (ground water, marine), Noise, Land and its characteristics- Pollution control and management- Environmental monitoring & sampling, Physical, chemical and biological methods and analysis- Air pollution- control and treatment strategies. Modes of Biological treatment methods for wastewater-aerobic digestion, anaerobic digestion, Anoxic digestion, the activated sludge process, Design and modeling of activated sludge processes, Aerobic digestion, Design of a trickling biological filter, Design of anaerobic digester.

UNIT III INDUSTRIAL WASTE MANAGEMENT 9

Industrial waste management- Dairy, Paper and Pulp, Textile, leather, hospital and pharmaceutical industrial waste management, e-waste- radioactive and nuclear power waste management- Solid waste management.

UNIT IV MODERN TOOLS OF BIOREMEDIATION 9

Molecular biology tools for Environmental management, rDNA technology in waste treatment, Genetically modified organisms in Waste management, Genetic Sensors, Metagenomics, Bioprospecting, Nanoscience in Environmental management, Phytoremediation for heavy metal pollution, Biosensors development to monitor pollution**.**

UNIT V RENEWABLE ENERGY SOURCES AND ENERGY MANAGEMENT 9

Alternate Source of Energy, Biomass as a source of energy, Biocomposting, Vermiculture, Biofertilizers, Organic farming, Biofuels, Biomineralization, Bioethanol and Biohydrogen, Bio-electricity through microbial fuel cell, energy management and safety.

TOTAL :45 PERIODS

OUTCOMES:

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

CO1 give solutions to the problems in global and native environment

CO2 gain knowledge about evolution of conventional and contemporary technologies to avoid environmental issues.

CO3 Implement the modern tools of biotechnology in an effective manner.

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2. Waste water Engineering Treatment, Disposal and Reuse. Metcalf & Eddy (1991) Mc Graw Hill.
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5. Environmental Biotechnology by Alan Scragg (1999); Longman.
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Course Articulation Matrix

Course Outcome Statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	give solutions to the problems in global and native environment	3	2	-	-	-	-	3	2	-	-	-	1
CO2	gain knowledge about evolution of conventional and contemporary technologies to avoid environmental issues.	3	2	3	-	-	-	3	1	-	-	-	2
CO3	Implement modern tools of biotechnology in an effective manner.	1	-	-	-	-	-	3	2	-	-	-	1
Overall CO		2	1	1	-	-	-	3	2	-	-	-	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT5072 ENZYME ENGINEERING AND TECHNOLOGY L T P C

3 0 0 3

OBJECTIVES

The course aims to,

- Teach principles of enzyme engineering and enzyme technology.
- Learn about immobilisation techniques and kinetics in enzyme technology.

UNIT I ENZYMES, COENZYMES AND COFACTORS 9

Enzymes: Enzyme as biological catalysts; activation energy, specificity, Enzyme action, active site, enzyme substrate complex, cofactors, Classification, Source of enzymes;production, isolation and purification of enzymes; Characterization in terms of pH,temperature, ionic strength, substrate and product tolerance, effects of metal ions;Coenzymes and cofactors: Coenzymes, classification of vitamins, role and mechanism of action of some important coenzyme (NAD+/NADP+, FAD, lipoic acid, tetrahydrofolate,B12-coenzyme), role of cofactors with specific examples.

UNIT II ENZYME KINETICS 9

Methods for investigating the kinetics of Enzyme catalysed reactions – order of reaction, initial velocity studies. Michaelis-Menten equation, Km and Vmax, enzyme inhibition; methods of plotting enzyme kinetics data; Enzyme turnover number, Solution of numerical problems. competitive, non-competitive, uncompetitive, irreversible; order of reaction,methods of plotting enzyme kinetics data; determination of Kcat, Km, Vmax, Ki, Half Life, effect of pH and Temperature on enzyme activity Multi Substrate enzymes and kinetics mechanisms;Enzyme induction, repression, covalent modification, Isoenzymes, allosteric effects.

UNIT III ENZYME ENGINEERING 9

Introduction, Random and rational approach of protein engineering; Directed evolutionand its application in Biocatalysis; various approaches of creating variant enzyme molecules; Future of Biocatalysis; Ideal biocatalyst.

UNIT IV IMMOBILIZED ENZYME TECHNOLOGY 9

Different techniques of immobilization of enzymes and whole cells; Advantages and disadvantages of immobilization; Cross linked enzymes, enzyme crystals, their use and preparation Kinetics of immobilized enzymes, design and operation of immobilized enzymes reactors; Type of reactors, classification, retention of enzymes in a reactor, kinetics of enzyme reactors; Reactor performance with inhibition, operation of enzyme reactors; case studies; Application and future of immobilized enzyme technology

UNIT V ENZYMATIC TRANSFORMATION 9

Functional group interconversion using enzymes (hydrolysis reaction, oxidation/reduction reactions, C-C bond formations). Reaction engineering for enzyme-catalyzed biotransformations. Catalytic antibodies. Biocatalysts from extreme Thermophilic and Hyperthermophilic microorganisms (extremozymes). The design and construction of novel enzymes, artificial enzymes, Biotransformation of drugs (hydroxylation of Steroids), Host Guest Complexation chemistry, enzyme design using steroid templates, enzymes for production of drugs, fine chemicals and chiral intermediates.

TOTAL :45 PERIODS

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OUTCOMES:

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

CO1 know about basics such as enzyme's classification, action and factors affecting its activity.

CO2 get knowledge about enzyme kinetics and different types of enzyme inhibition.

CO3 have exposure to various approaches of enzyme engineering and immobilization.

CO4 learn the applications of enzymes.

REFERENCES

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7. Wang, D. I. C. (1979). Fermentation and Enzyme Technology. Wiley. New York.
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Course Articulation Matrix

Course Outcome Statements		Programme Outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	know about basics such as enzyme's classification, action and factors affecting its activity.	3	1	1	1	1	-	-	-	1	-	-	2
CO2	get knowledge about enzyme kinetics and different types of enzyme inhibition.	3	1	2	1	1	-	-	-	1	-	-	2
CO3	have exposure to various approaches of enzyme engineering and immobilization.	3	1	2	1	3	-	1	1	1	-	2	2
CO4	learn the applications of enzymes.	3	1	2	1	1	-	1	1	1	-	2	2
Overall CO		3	2	2	1	2	-	1	1	1	-	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5073 **NANOBIOTECHNOLOGY** **L T P C**
3 0 0 3

OBJECTIVES

The course aims to

- provide fundamental concepts of nanotechnology
- use the fundamental knowledge for the application of nanotechnology to biological sciences including nanomedicine.

UNIT I NANOSCALE AND NANOBIOTECHNOLOGY 9

Introduction to Nanoscience and Nanotechnology; Milestones in Nanotechnology; Overview of Nanobiotechnology and Nanoscale processes; Physicochemical properties of materials in Nanoscales.

UNIT II FABRICATION AND CHARACTERIZATION OF NANOMATERIALS 9

Types of Nanomaterials (Quantum dots, Nanoparticles, Nanocrystals, Dendrimers, Buckyballs, Nanotubes); Gas, liquid, and solid –phase synthesis of nanomaterials; Lithography techniques (Photolithography, Dip-pen and Electron beam lithography); Thin film deposition; Electrospinning. Bio-synthesis of nanomaterials.

UNIT III PROPERTIES AND MEASUREMENT OF NANOMATERIALS 9

Optical Properties: Absorption, Fluorescence, and Resonance; Methods for the measurement of nanomaterials; Microscopy measurements: SEM, TEM, AFM and STM. Confocal and TIRF imaging.

UNIT IV NANOBIOLOGY AND BIOCONJUGATION OF NANOMATERIALS 9

Properties of DNA and motor proteins; Lessons from nature on making nanodevices; Reactive groups on biomolecules (DNA & Proteins); Surface modification and conjugation to nanomaterials. Fabrication and application of DNA nanowires; Nanofluidics to solve biological problems.

UNIT V NANO DRUG DELIVERY AND NANOMEDICINE 9

Properties of nanocarriers; drug delivery systems used in nanomedicine; Enhanced Permeability and Retention effect; Blood-brain barrier; Active and passive targeting of diseased cells; Health and environmental impacts of nanotechnology.

TOTAL : 45 PERIODS

OUTCOMES

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

CO1 understand fundamental concepts of nanotechnology and nanomaterials
CO2 have knowledge on the fabrication and characterization of nanomaterials
CO3 understand nanobiology and modification of nanomaterials
CO4 know nano-based drug delivery and nanomedicine

REFERENCES

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Course Articulation Matrix

Course Outcome Statement		Programme Outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	understand fundamental concepts of nanotechnology and nanomaterials	2					2				1		2
CO2	have knowledge on the fabrication and characterization of nanomaterials	3		2			2		1				2
CO3	understand nanobiology and modification of nanomaterials	2	2		1	1	2	2	1				3
CO4	know nano-based drug delivery and nanomedicine	3	2		1	1	2	2	2	1		1	3
Overall CO		3	1	1	1	1	2	1	1	-	-	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT5002 BIOSAFETY AND BIOETHICS L T P C
3 0 0 3

OBJECTIVES

The course aims to

- facilitate students to understand the basic definitions of biosafety, bioethics, biopolicy and good laboratory procedure and practices,
- enable students to understand various standard operating procedures for biotechnology research,
- know the legal and institutional framework for biosafety in national and international levels and knowledge about various agreements and protocols for biosafety

UNIT I SAFETY COMPONENTS IN INDUSTRIES 9

Need for safety in industries; Safety Programmes – components and realization; Potential hazards – extreme operating conditions, toxic chemicals; safe handling

UNIT II SAFETY PROCEDURE AND CASE STUDIES 9

Implementation of safety procedures – periodic inspection and replacement; Accidents – identification and prevention; promotion of industrial safety EG: Government Regulator's Approach to Risk - Chernobyl and Bhopal Case Studies.

UNIT III RISK ANALYSIS 9

Overall risk analysis--emergency planning-on site & off site emergency planning, risk management ISO 14000, EMS models case studies. Quantitative risk assessment – rapid and comprehensive risk analysis; Risk due to Radiation, explosion due to over pressure, jet fire-fire ball.

UNIT IV RESPONSIBILITIES AND RIGHTS 9

Collegiality and Loyalty – Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) - Discrimination.

UNIT V GLOBAL ISSUES 9

Multinational Corporations – Business Ethics - Environmental Ethics – Computer Ethics - Role in Technological Development – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Honesty – Moral Leadership – Sample Code of Conduct.

TOTAL :45 PERIODS

OUTCOMES:

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

CO1 define biosafety and bioethics in the context of modern biotechnology

CO2 familiarized with the standard operating procedures for biotechnology research and biosafety levels

CO3 aware of the social and ethical issues related to plant/animal biotechnology and to understand the relevance of intellectual property rights

REFERENCES

1. Fawatt, H.H. and Wood, W.S., "Safety and Accident Prevention in Chemical Operation", Wiley Interscience, 1965.
2. Marcel, V.C., Major Chemical Hazard- Ellis Harwood Ltd., Chi Chester, UK, 1987.
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Course Articulation Matrix

Course Outcome Statement		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	define biosafety and bioethics in the context of modern biotechnology	2	1	2	2	2	1	1	2	1	1	2	3
CO2	familiarized with the standard operating procedures for biotechnology research and biosafety levels	2	2	2	2	3	2	3	3	1	1	1	3
CO3	To be aware of the social and ethical issues related to plant/animal biotechnology and to understand the relevance of intellectual property rights	3	2	2	2	3	3	3	3	2	1	1	3
Overall CO		2	2	2	2	2	3	3	3	3	1	1	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5003	BIOMEDICAL DEVICES	L T P C
		3 0 0 3

OBJECTIVES

The course aims to

- familiarize students with emerging trends in medical devices
- apply the knowledge for early detection, selection of appropriate treatment, monitoring treatment effectiveness and disease surveillance

UNIT I SENSORS AND TRANSDUCERS 12

Rationale of electronic biosensors; Essence of three types of electronic biosensors (i.e., potentiometric, amperometric, and cantilever-based sensors); Three essential metrics that define modern electronic sensors; detection time, sensitivity, and selectivity; Physics of detection time that allows one to organize every available sensor in a systematic way; Fundamental limits of detection of various classes of sensors; Opportunities and challenges of integrating sensors in a system platform.

Principles and applications of Calorimetric, Piezoelectric, semiconductor, impedimetric, based transducers; Biochemical Transducers: Electrode theory: electrode-tissue interface, metal-electrolyte interface, electrode-skin interface, electrode impedance, electrical conductivity of electrode jellies and creams

UNIT II OPTICAL SENSORS AND BIO RECOGNITION SYSTEMS 9

Photo detectors, optical fiber sensors, indicator mediated transducers; General principles of optical sensing, optical fiber temperature sensors; Pulse sensor: photoelectric pulse transducer, strain gauge pulse transducer

Enzymes; Oligonucleotides Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Immunoreceptors; Chemoreceptors.

UNIT III ELECTRODES AND IMMOBILIZATION 9

Microelectrodes, body surface electrodes, needle electrodes, pH electrode, specific ion electrodes/ Ion exchange membrane electrodes, enzyme electrodes; Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, Calomel electrodes; Enzyme immobilization; Peptide immobilization; Antibody immobilization; Oligonucleotides and Nucleic Acid immobilization; Cell immobilization; Mono-enzyme electrodes; Bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes.

UNIT IV FUNDAMENTALS AND APPLICATIONS OF MICROFLUIDICS 6

Capillary flow and electro kinetics; Micro pump, Micro mixers, Micro reactors, Micro droplets, Micro particle separators; Micro fabrication techniques (different types of lithography methods); Application of micro-fluidics (e.g. Lab- in –Chip).

UNIT V CASE STUDY ON VARIOUS DIAGNOSTIC APPLICATION 9

Biomarkers: Disease and pathogen specific information, availability by sample type Applications(blood, serum, urine, sputum, saliva, stool, mucus); Specificity, sensitivity, shelf life, portability; Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable Sensors for long-term monitoring; Drug development and detection; Environmental monitoring; Examples of various diseases (Cancer, HIV/AIDS, Tuberculosis, Malaria, Lymphatic Filariasis, Schistosomiasis, Dengue, Chikungunya).

TOTAL : 45 PERIODS

OUTCOMES:

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

CO1 understand the principles of biosensors classification and construction.

CO2 appreciate basic configuration/distinction of optical sensors and bio-recognition systems

CO3 have basic understanding on electrode selection, bio-immobilization and microfluidics

CO4 have case study understanding of developing applications in diagnostics

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REFERENCES

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Course Articulation Matrix

Course Outcome Statements		Programme Outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	understand the principles of biosensors classification and construction.	3	2	2	1	2	1	1	-	-	-	-	-
CO2	appreciate basic configuration/distinction of optical sensors and bio-recognition systems	3	3	3	2	3	1	3	-	-	-	-	1
CO3	have basic understanding on electrode selection, bio-immobilization and microfluidics	3	3	3	3	3	1	3	-	1	-	1	2
CO4	have case study understanding of developing applications in diagnostics	3	3	3	3	3	2	2	1	2	-	3	3
Overall CO		3	3	3	2	3	1	2	-	1	-	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT5004 BIOPROCESS MODELING AND SIMULATION L T P C
2 0 2 3

OBJECTIVES

The course aims to

- introduce the fundamental aspects of modeling of various biological systems
- address the various modeling paradigms, based on the level of detail, the extent of data available as well as the question the model must address.
- outline the applications of such modeling techniques

UNIT I MODELING OF BIOLOGICALSYSTEMS 12

Modeling Principles, model development from first principles. Modeling approaches for Biological systems – structured and unstructured systems; Compartment models; Deterministic and stochastic approaches for modeling structured systems.

UNIT II MODELLING OF DIFFUSION SYSTEMS (BIOFILM AND IMMOBILIZED ENZYME SYSTEMS 12

External mass transfer, Internal diffusion and reaction within biocatalysts, derivation of finite model for diffusion-reaction systems, dimensionless parameters from diffusion-reaction models,the effectiveness factor concept, case studies; oxygen diffusion effects in a biofilm, biofilm nitrification

UNIT III MODELING BIOREACTOR 12

Bioreactor modelling: Ideal and non-ideal bioreactors; Stirred tank models; characterization of mass and energy transfer distributions in stirred tanks, Tower Reactor Model; Flow modeling, bubble column flow models, mass transfer modeling, structured models for mass transfer in tower reactors, process models in tower reactors, airlift models,

UNIT IV LINEAR SYSTEM ANALYSIS 12

Study of linear systems, linearization of non-linear systems; Simulation of linear models using MATLAB; Parameter estimation and sensitivity analysis; Steady state and unsteady state systems; stability analysis; Case study of recombinant protein production.

UNIT V HYBRID AND OTHER MODELING TECHNIQUES 12

Advanced modeling techniques such as fuzzy logic, neural network, hybrid systems and fuzzy logic systems; case studies.

TOTAL:60 PERIODS

OUTCOMES:

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

CO1 understand the modeling of biological systems and bioreactors.

CO2 design new models for biological systems, biofilm and immobilized enzyme systems, and bioreactors

CO3 carry out simulation of models using software (MATLAB).

CO4 analyze the simulation studies and stability and sensitivity of the system.

REFERENCES

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Course Articulation Matrix

Course Outcome Statements		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	understand the modeling of biological systems and bioreactors.	3	1	1	1	-	-	-	-	-	-	-	-
CO2	design new models for biological systems, biofilm and immobilized enzyme systems, and bioreactors	3	2	3	3	2	2	-	-	1	-	1	1
CO3	carry out simulation of models using software (MATLAB)	3	2	2	1	3	1	-	-	1	-	1	1
CO4	analyze the simulation studies and stability and sensitivity of the system.	3	3	3	3	1	1	-	-	2	-	1	1
Overall CO		3	2	2	2	2	1	-	-	1	-	1	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT5005 MOLECULAR DIAGNOSTICS L T P C
3 0 0 3

OBJECTIVES

The course aims to

- sensitize students about recent advances in molecular biology and various facets of molecular medicine.
- utilize the techniques of molecular medicine for pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

UNIT I GENOME BIOLOGY: HEALTH, DISEASE DETECTION AND ANALYSIS 12

DNA, RNA and Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs.
PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF MS; Bioinformatics data acquisition & analysis.

UNIT II DIAGNOSTIC METABOLOMICS 6

Metabolite profile for biomarker detection in the body fluids/tissues under various metabolic disorders by making use of LCMS & NMR technological platforms

UNIT III DETECTION AND IDENTITY OF MICROBIAL DISEASES 9

Direct detection & identification of pathogenic-organisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics.

UNIT IV DETECTION OF INHERITED DISEASES 9

Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: - Fragile X Syndrome: Paradigm of the new mutational mechanism of the unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in the growing number of familial cancer syndromes.

UNIT V MOLECULAR ONCOLOGY AND QUALITY ASSURANCE AND CONTROL 9

Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies. Quality oversight; regulations and approved testing.

TOTAL:45 PERIODS

OUTCOMES:

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

CO1 understand various facts of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases.

CO2 analyze various immunomolecular technique.

CO3 analyze various high-end technique such as SELDI-TOF MS, LCMS and NMR.

CO4 understand the cause and detection of some of the inherited diseases and cancer using molecular diagnostics tools.

REFERENCES

1. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
2. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill.
3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press.
4. Coleman, W. B., & Tsongalis, G. J. (1997). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press.

Course Articulation Matrix

Course Outcomes Statements		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	understand various facts of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases.	3	-	2	1	-	-	-	-	-	-	-	-
CO2	learn and analysis various immunomolecular technique.	3	2	2	2	3	-	-	2	1	-	1	2
CO3	learn and analysis various high-end technique such as SELDI-TOF MS, LCMS and NMR.	3	2	2	1	3	-	-	2	1	-	1	2
CO4	understand the cause and detection of some of the inherited diseases and cancer using molecular diagnostics tools.	3	2	2	-	3	-	-	2	2	-	1	2
Overall CO		3	2	2	1	3	-	-	2	1	-	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5071 APPLIED STATISTICS FOR BIOLOGISTS L T P C
2 1 0 3

OBJECTIVES

The course aims to

- study the fundamentals of statistics
- apply fundamentals of statistics in relation to biological and biotechnological problems

UNIT I PROBABILITY 9

Random variable-sample spaces-Events-Axiomatic approach to probability, conditional probability, additional theorem, Multiplication theorem, Baye's theorem. Problems solving for continuous and discrete random variables, Distribution function, Expectation with properties, Moments, Mean, Variance. Problems solving for continuous and discrete distributions.

UNIT II DISTRIBUTION 9

Bivariate distribution, Conditional and Marginal distribution. Discrete distribution, Binomial, Poisson, Geometric distribution, Continuous distribution. Normal Exponential and Negative Exponential. Gamma distributions, Properties and Problem solving.

UNIT III METHODS OF CORRELATION 9

Correlation coefficient, Properties, Problems. Rank correlation, Regression equations Problems. Curve fitting by the method of least squares, fitting curves of the form ax+b,ax2+bx+c,abx and axb. Bivariate correlation application to biological problems.

UNIT IV SAMPLING 9

Concept of sampling, Methods of sampling, sampling distributions and Standard Error. Small samples and large samples. Test of hypothesis: Type I, Type II Errors. Critical region, Large sample tests for proportion, Mean-Exact test based on normal, t, f and chi-square distribution. Problems, Test of goodness of fit.

UNIT V DESIGN OF EXPERIMENTS 9

Basic principles of experimentation. Analysis of variance, one-way, Two-way classifications. Randomised block design, Latin square design. Problems solving.

TOTAL: 45 PERIODS

OUTCOMES

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

CO1 understand basic probability and distribution in statistics.
CO2 learn correlation and regression with sampling in biological experiments.
CO3 design experiment and justify the statistical significance of the results of the experiment in testing hypothesis
CO4 understand and apply statistical methods of analysis in biological research

REFERENCES

1. Kapoor, V. C. "Elements of Mathematical statistics", 2018
2. Vittal, P.R. and V.Malini."Statistical and Numerical Methods". Margham Publications, 2012.
3. Veerarajan,T. "Probability, Statistics and Random Processes".3rd Edition., Tata Mc Graw-Hill, 2008.
4. Johnson, R. A."Miller & Freund's Probability and Statistics for Engineers". 6th ed. PHI, 2003.
5. Arora, P. N. Smeet Arora, and Arora, S. "Comprehensive Statistical Methods". S . Chand & Co, 2010
6. Spiegel, Murray R., J.Schiller and R.Alu Srinivasan."Schaum's Outlines Probability and Statistics".2nd Edition. Tata Mc Graw-Hill 2000.
7. Kandasamy, P. K. Thilagavathi & K. Gunavathi."Probability Statistics and Queuing Theory". S. Chand & Co., 2004

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Course Articulation Matrix

Course Outcomes Statements		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	understand basic probability and distribution in statistics.	3	-	-	1	-	-	-	-	-	-	-	-
CO2	learn correlation and regression with sampling in biological experiments.	3	3	3	2	-	-	-	1	1	-	-	1
CO3	design experiment and justify the statistical significance of the results of the experiment in testing hypothesis.	3	3	3	1	-	-	-	1	1	-	2	3
CO4	understand and apply statistical methods of analysis in biological research.	3	3	3	2	-	-	-	1	1	-	3	3
Overall CO		3	3	3	2	-	-	-	1	1	-	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT5006 BIOFUELS AND PLATFORM CHEMICALS L T P C
3 0 0 3

OBJECTIVES

The course aims to

- build a solid foundation of knowledge and skills to study about the conversion and production of biomass to biofuels.
- understand the importance of value added products and renewable materials in context to the global and environmental needs.
- analyze and transfer the knowledge related to the implementation of technologies in a innovative way for the enhanced production of biofuels and chemicals.

UNIT I INTRODUCTION 9

Cellulosic Biomass availability and its contents. Lignocellulose as a chemical resource. Physical and chemical pretreatment of lignocellulosic biomass. Cellulases and lignin degrading enzymes.

UNIT II ETHANOL 9

Ethanol as transportation fuel and additive; bioethanol production from carbohydrates; engineering strains for ethanol production from variety of carbon sources to improved productivity.

UNIT III BIODIESEL 9

Chemistry and Production Processes; Vegetable oils and chemically processed biofuels; Biodiesel composition and production processes; Biodiesel economics; Energetics of biodiesel production and effects on greenhouse gas emissions Issues of ecotoxicity and sustainability with ; expanding biodiesel production

UNIT IV OTHER BIOFUELS 9

Biodiesel from microalgae and microbes; biohydrogen production; biorefinery concepts

UNIT V PLATFORM CHEMICALS 9

Case studies on production of C3 to C6 chemicals such as Hydroxy propionic acid, 1,3 propanediol, propionic acid, succinic acid, glucaric acid, cis-cis muconic acid.

TOTAL:45 PERIODS

OUTCOMES:

,At the end of the course the students will be able to
CO1 gain knowledge about the sources of biomass for alternative energies
CO2 apply technologies to replace the depleting energy with other energy such as bio hydrogen and bio refinery
CO3 use of cost effective and sustainable feed stocks

REFERENCE

1. Lee, Sunggyu; Shah, Y.T. “Biofuels and Bioenergy”. CRC / Taylor & Francis, 2013.

Course Articulation Matrix

Course Outcomes Statement		**Programme Outcome (PO)**											
		PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO1	gain knowledge about the sources of biomass for alternative energies	1	-	-	-	-	1	-	1	2	-	1	2
CO2	apply technologies to replace the depleting energy with other energy such as bio hydrogen and bio refinery	2	-	-	-	-	2	-	2	1	-	1	1
CO3	use of cost effective and sustainable feed stocks	1	-	-	-	-	1	-	1	2	-	1	2
Overall CO		1	-	-	-	-	1	-	1	2	-	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5007 FOOD PROCESSING AND BIOTECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- make the students understand the principles of food chemistry and the role of enzymes in food processing
- make them understand the role of microbes in food preservation, spoilage as well as food borne infections
- make them understand the role of various process technology used by food industries and to apply them

UNIT I FOOD CHEMISTRY 9

Constituent of food – contribution to texture, flavour and organoleptic properties of food; food additives – intentional and non-intentional and their functions; enzymes in food processing.

UNIT II FOOD MICROBIOLOGY 9

Sources and activity of microorganisms associated with food; food fermentation; food chemicals; food borne diseases – infections and intoxications, food spoilage – causes.

UNIT III FOOD PROCESSING 9

Raw material characteristics; cleaning, sorting and grading of foods; physical conversion operations – mixing, emulsification, extraction, filtration, centrifugation, membrane separation, crystallization, heat processing.

UNIT IV FOOD PRESERVATION 9

Use of high temperatures – sterilization, pasteurization, blanching, asceptic canning; frozen storage – freezing curve characteristics. Factors affecting quality of frozen foods; irradiation preservation of foods

UNIT V MANUFACTURE OF FOOD PRODUCTS 9

Bread and baked goods, dairy products – milk processing, cheese, butter, ice-cream, vegetable and fruit products; edible oils and fats; meat, poultry and fish products; confectionery, beverages.

TOTAL :45 PERIODS

OUTCOMES:

At the end of the course the students able to

CO 1 understand the basics of food chemistry and the role of enzymes

CO 2 know the importance of microbes in food industry

CO 3 apply the various process technology in food industries

REFERENCES

1. Coultate T.P. Food – The chemistry of its components, 2nd ed., Royal society, London, 1992
2. Sivasankar B. Food processing and preservation, Prentice Hall of India Pvt.Ltd., New Delhi, 2002
3. Fennema O.R. ed. Principles of food science : Part I, Food chemistry, Marcel Dekker, New York, 1976
4. Frazier W.C. and Westhoff D.C. Food Microbiology, 4th ed. McGram-Hill Book Co., New York, 1988.
5. Brenner, J.G., Butters, J.R., Cowell, N.D. and Lilly, A.E.V. Food engineering operations, 2nd ed., Applied Sciences Pub.ltd., London,1979
6. Pyke, M. Food Science and Technology , 4th ed., John Murray, London, 1981

Course Articulation Matrix

Course Outcome Statement		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	understand the basics of food chemistry and the role of enzymes	3	-	1	1	1	-	-	2	-	-	-	2
CO2	know the importance of microbes in food industry	2	-	1	1	1	-	-	2	-	-	-	2
CO3	apply the various process technology in food industries	2	2	2	1	1	-	-	2	-	-	-	2
Overall CO		2	2	1	1	1	-	-	2	-	-	-	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

BT5008 BIOSEPARATION TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- equip the students with all techniques required in the purification of proteins
- give them knowledge about downstream processing of large biomolecules and also important antibiotics and immunoacids.

UNIT I INTRODUCTION TO BIOSEPARATION 4

Characterization of biomolecules and fermentation broth. Guidelines to recombinant protein purification.

UNIT II SOLID-LIQUID SEPARATION AND CELL DISRUPTION 6

Solid liquid separation- microfiltration and centrifugation – theory and design for scaleup operation. Cell disruption – Homogeniser , Dynomill – Principle and factors affecting disruption. Batch and Continuous Operation. Cell disruption by chemical methods.

UNIT III CONCENTRATION AND PURIFICATION 7

Liquid- liquid extraction – theory and practice with emphasis on Aqueous two phase extraction. Solid liquid extraction. Precipitation techniques using salt and solvent. Separation by ultrafiltration, Dialysis, Electrophoresis.

UNIT IV CHROMATOGRAPHY 15

Theory, practice and selection of media for – Gel filtration chromatography, Ion-exchange chromatography, Hydrophobic interaction chromatography, reverse-phase chromatography, Affinity chromatography – Metal affinity chromatography, Dye affinity chromatography, Immunosorbent Affinity chromatography and Expanded bed chromatography. Scale-up criteria for chromatography. Calculation of number of theoretical plates and design.

UNIT V FINAL POLISHING AND CASE STUDIES 13

Freeze drying, spray drying and crystallization. Purification of cephalosporin, aspartic acid, Recombinant Streptokinase, Monoclonal antibodies, Tissue plasminogen activator, Taq Polymerase and Insulin.

TOTAL : 45 PERIODS

OUTCOMES:

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

CO1. have a comprehensive understanding of the physicochemical properties of biotechnological products and economics of downstream processing

CO2. get knowledge about equipment selection and design of mechanical separation process for recovery of biotechnological products

CO3. identify and optimize the suitable bioproduct isolation process at laboratory and pilot scale

CO4. have a thorough understanding of chromatographic separation processes and equipment selection

CO5. have complete knowledge of stability of biotechnology products and should be capable of formulation and stabilization for enhanced shelf-life. Apply principles of various unit operations used in downstream processing and enhance problem solving techniques

REFERENCES

1. Roger Harrison, Paul Todd, Scott Rudge and Dimitri Petrides, "Bioseparations Science and Engineering", Oxford University Press, 2003
2. Ghosh, Raja "Principles of Bioseparations Engineering". World Scientific, 2006
3. Belter, P.A., E.L. Cussler and Wei-Houhu "Bioseparations – Downstream Processing for Biotechnology", John Wiley, 1988.
4. Michael C Flickinger, Encyclopedia of Downstream Industrial Biotechnology, John Wiley &Sons, 2010
5. Michael R. Ladisch, Bioseparations Engineering, Wiley Interscience, 2001
6. Georgios Carta and AloisJungbauer, Protein Chromatography, Wiley-VCH, 2010

Course Articulation Matrix

Course Outcomes Statement		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	have a comprehensive understanding of the physicochemical properties of biotechnological products and economics of downstream processing	3	3	3	3	3	3	--	-	-	-	-	-
CO2	get knowledge about equipment selection and design of mechanical separation process for recovery of biotechnological products	3	3	3	3	3	3	--	-	-	-	-	-
CO3	identify and optimize the suitable bioproduct isolation process at laboratory and pilot scale	3	3	3	3	3	3	-	-	-	-	--	-
CO4	have a thorough understanding of chromatographic separation processes and equipment selection	3	3	3	3	3	3	-	-	-	-	-	-
CO5	have complete knowledge of stability of biotechnology products and should be capable of formulation and stabilization for enhanced shelf-life	2	2	2	2	2	2	-	-	-	-	-	-
Overall CO		3	3	3	3	3	3	-	-	-	-	-	-

Attested

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5009 PHARMACEUTICAL BIOTECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- equip the students with basics of pharmaceutical dosage form development
- educate them about the principles of applying the same for developing biopharamaceutical formulations.

UNIT I INTRODUCTION 8

History of pharmaceutical industry, Drugs discovery and Development phases; Drugs and Cosmetics ACT and regulatory aspects; Definition: Generics and its advantages; Biogenerics and Biosimilars; The role of patents in the drug industry; Protein-based biopharmaceuticals; International Non-proprietary Names (INN) nomenclature system biosimilars regulation.

UNIT II DOSAGE FORM: SCIENCE, PHARMACOKINETICS & PHARMACODYNAMICS 10

Definition of Dosage forms, Classification of dosage forms (solid unit dosages – Tablets, capsules; liquids – solutions, lotions, suspension etc; semi-solid – ointments, creams, gel, suppositories, etc; Parenterals, Aerosols etc), Introduction to pharmacokinetics and pharmacodynamic principles (factors affecting the ADME process); bioavailability, bioequivalence.

UNIT III DRUG DELIVERY/CHARACTERISATION OF BIOGENERIC RECOMBINANTS 9

Advanced drug delivery systems – controlled release, transdermals, liposomes and drug targeting. Approaches to the characterization of biosimilars; Problems in characterizing biologics (Types of biologic, Peptides, Non-glycosylated proteins, Glycosylated proteins, Monoclonal antibodies); Equivalence issues; Post-translational modifications; Effect of microheterogeneity.

UNIT IV PHARMACOLOGY PRINCIPLES, CLASSIFICATION OF DRUGS AND MECHANISM 10

Understanding principles of pharmacology, pharmacodynamics Study of a few classes of therapeutics like laxatives, antacids and drugs used in peptic ulcers, drugs used in coughs and colds, analgesics, contraceptives, antibiotics (folate inhibitors, protein synthesis inhibitors, DNA inhibitors), hormonal agonists and antagonists, anticancer drugs.

UNIT V CASE STUDIES ON BIOPHARMACEUTICAL PRODUCT DEVELOPMENT 8

Erythropoietin, Insulin, Somatotropin, Interleukin-2, Interferon Granulocyte-macrophage-CSF, Factor VIIa, Factor IX, Factor VIII, Tissue plasminogen activator, Monoclonal antibodies and engineered Mabs

TOTAL :45 PERIODS

OUTCOMES

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

CO1 enable the students to learn the principles of drug development, and regulations
CO2 have insight about formulation of dosage forms and characterization.
CO3 understand the principles of drug classification, pharmacology and applications

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REFERENCES

1. Gareth Thomas. Medicinal Chemistry. An introduction. John Wiley. 2000.
2. Katzung B.G. Basic and Clinical Pharmacology, Prentice Hall of Intl. 1995.
3. T.V. Ramabhadran. Pharmaceutical Design And Development : A Molecular Biology Approach, Ellis Horwood Publishers, New York, 2005
4. Goodman & Gilman's The Pharmacological Basis of Therapeutics,11th edition, Mc Graw-Hill Medical Publishing Division New York, 2006.
5. Sarfaraz K. Niazi, Handbook of Biogeneric Therapeutic Proteins: Regulatory, Manufacturing, Testing, and Patent Issues, CRC Press, 2006.
6. Rodney J Y Ho, MILO Gibaldi, Biotechnology & Biopharmaceuticals Transforming proteins and genes into drugs, 1st Edition, Wiley Liss, 2003.
7. Brahmankar D M, Jaiswal S B, Biopharmaceutics and Pharmacokinetics A Treatise, Vallabh Publisher, (1995, reprint 2008)

Course Articulation Matrix

Course Outcome Statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	enable the students to learn the principles of drug development, and regulations	3	3	3	1	1	-	-	-	-	-	1	1
CO2	have insight about formulation of dosage forms and characterization.	3	3	3	1	2	1	1	-	1	-	1	2
CO3	understand the principles of drug classification, pharmacology and applications	3	3	3	1	2	1	1	-	1	-	2	2
Overall CO		3	3	3	1	-	1	1	-	1	-	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5010 TECHNIQUES IN MOLECULAR BIOLOGY AND GENETIC ENGINEERING

L T P C
3 0 0 3

OBJECTIVES

The course aims to

- enlighten key molecular biology and genetic engineering techniques
- apply the latest techniques in current biological research as well as in biotechnology industries.

UNIT I VECTOR SYSTEMS 9

Overview of tools in recombinant DNA technology. Artificial chromosomes – YACs and BACs. Principles for maximizing gene expression – expression vectors, pMal, GST, pET-based vectors. Protein purification – His-tag, GST-tag and MBP-tag. Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri plasmids as vectors, yeast vectors, shuttle vectors.

UNIT II ASSAY TECHNIQUES IN MOLECULAR BIOLOGY 8

Nuclease protection assays, Nuclease S1 mapping, Reporter assays – Mono and dual reporter assays, Electrophoretic mobility shift assay (EMSA)/Gel shift assay, Run-off transcription assay, Phage display, Ribosome display, Gene silencing – siRNA and Morpholino.

UNIT III HIGH-THROUGHPUT DNA SEQUENCING 9

Preparation of Next Generation Sequencing (NGS) libraries: Fragmentation versus tagmentation, end repair, clonal amplification – Bridge PCR and emulsion PCR. Basics and steps involved in NGS platforms: Illumina/Solexa, Roche 454, Ion-torrent and Pacific biosciences. Current status of Oxford nanopore sequencing. Principles of Mate pair sequencing, ChIP-seq, RIP/CLIP-Seq, Methyl seq – Restriction enzyme, enrichment and bisulfite treatment strategies.

UNIT IV GENE EXPRESSION ANALYSIS 10

Overview of gene expression and its significance. Hybridization methods: Southern and Northern. PCR methods: Reverse transcriptase PCR, End point Vs. Real time PCR, Relative quantitation, Absolute quantification – Standard curve method and digital PCR. Endogenous/loading controls.High throughput analysis:Multiplex PCR, Microarray, Serial analysis of gene expression (SAGE) and Small Amplified RNA-SAGE (SAR-SAGE), Total analysis of gene expression (TOGA), Gene calling, RNA-seq and Ribosome profiling.

UNIT V GENOME EDITING TECHNOLOGIES 9

Basicsand applications of genome editing methods - Zinc-finger nuclease (ZFN), Transcription activator-like effector nucleases (TALEN), Meganucleases, CRISPR-Cas systems – Types and applications, Homing endonucleases, Transposons and Cre/lox P systems.Gene delivery systems – Physicochemical methods and viral vectors.

TOTAL :45 PERIODS

Attested

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OUTCOMES:

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

CO1 understand strength and limitations of tools and techniques used in molecular biology and genetic engineering

CO2 understand basic principles and steps involved in DNA/RNA sequencing methods and current protocols of specific vs global gene expression analysis

CO3 understand the current techniques involved in gene editing to generate appropriate genetically modified organisms

REFERENCES

1. Steven R. Head, Phillip Ordoukhanian, Daniel R. Salomon. "Next Generation Sequencing: Methods and protocols"1st Edition, Humana Press, 2018
2. KrishnaraoAppasani. "Genome Editing and Engineering" Cambridge University press 2018.
3. Raghavachari Nalini, Garcia-Reyero Natàlia. "Gene expression analysis: Methods and protocols" 1st Edition, Humana Press, 2018.
4. Primrose SB and Twyman RB. "Principles of Gene manipulation and Genomics". 7th Edition, Wiley-Blackwell, 2006.
5. Green MR and Sambrook J. "Molecular Cloning: A Laboratory Manual". 4th Edition, CSHL press, 2012.

Course Articulation Matrix

Course outcome Statements		Programme Outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	understand strength and limitations of tools and techniques used in molecular biology and genetic engineering	3	3	3	2	3	3	3	1	1	-	-	3
CO2	understand basic principles and steps involved in DNA/RNA sequencing methods and current protocols of specific vs global gene expression analysis	3	3	3	2	3	3	3	1	1	-	-	3
CO3	understand the current techniques involved in gene editing to generate appropriate genetically modified organisms	2	3	3	2	2	3	3	3	1	-	-	2
Overall CO		3	3	3	2	3	3	3	1	1	-	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5011 PLANT GENETIC ENGINEERING AND BIOTECHNOLOGY L T P C
2 0 2 3

OBJECTIVES

The course aims to

- provide knowledge on the concepts of plant tissue culture and genetic engineering principles,
- make the students aware of the status of plant transgenics and regulations
- enlighten them about molecular pharming and other industrial applications

UNIT I INTRODUCTION TO PLANT BIOLOGY 12

Totipotency and plasticity, Explants. Cultures - single cell, callus, cell-suspension, protoplast, leaf, mroot, shoot tip and meristems, embryo, anther, microspore and ovary culture. Somatic embryogenesis, organogenesis and hardening. Industrial applications of tissue culture Phytopharmaceuticals: Major classes of phytochemicals (secondary metabolites) and their pharmacological properties Liquid Cultures of Plant Cells: Initiation and maintenance of callus and suspension cultures; Bioreactors – types and principles and their applications for secondary metabolites

UNIT II PLANT TRANSFORMATION VECTORS 12

Features of a plant transformation vector. Constitutive, inducible and tissue specific promoters, terminators and regulatory elements; Selectable markers and reporter genes; Modification of heterologous gene (animals, microbes) for plant transformation Nuclear and plastid transformation; Agrobacterium mediated and direct gene transfer methods. Binary vectors, Gateway vectors and RNAi vectors.

UNIT III PLANT METABOLIC ENGINEERING 12

Herbicide tolerance [Round Up Ready], Bt crops, Golden Rice, Transgenic crops designed for tolerance to abiotic and biotic stress. Transgenic systems to derive carbohydrates , plantibodies, edible vaccines, enzymes, biopharmaceuticals, bioplastics, biofuel, silk and elastin. Gene to functional protein processing steps in plants; Elicited cell cultures for maximizing yield of metabolites

UNIT IV MARKER ASSISTED BREEDING AND IPR 12

Phenotypic, enzyme and molecular markers, co-dominant and dominant markers, Basics- linkage analysis and QTL mapping, Global status and bio-safety concerns for production and release of transgenic plants. Plant breeders rights, copyright, trade mark and patents.

UNIT V APPLICATIONS OF PLANT BIOTECHNOLOGY 12

1. Preparation of media
2. Initiation and Organ culture
3. Callus induction and propagation
4. Protoplast Isolation
5. DNA isolation from plant tissues
6. Encapsulation of cells/ tissues
7. Plant transformation and analysis of transgene expression

TOTAL : 60 PERIODS

OUTCOMES:

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

CO1 acquire knowledge and skills on plant tissue culture techniques

CO2 acquire knowledge on plant genetic engineering, molecular markers and transgenic regulations through case studies

CO3 develop creative thinking abilities in problem solving

CO 4 become proficient in aseptic techniques

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REFERENCES

1. Adrian Slater, N. W. Scott and M. Fowler. 2014. Plant Biotechnology: The Genetic Manipulation of Plants, Second Edition, Oxford University Press, UK.
2. Roberta H. Smith. 2013. Plant Tissue Culture Techniques and Experiments, 3rd Edition, Elsevier Inc., UK.
3. Bahadur, B., M.V. Rajam, L. Sahijram and K.V. Krishnamurthy. 2015. Plant Biology and Biotechnology, Vol. 2, Springer, New Delhi.
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7. J.Hammond, P.McGarvey and V.Yusibov (Eds): Plant Biotechnology. Springer Verlag, 2000.
8. R.J.Henry: Practical Application of plant molecular biology. Chapman and Hall.1997
9. J. Reinert und P.S. Bajaj (Herausg.): Applied and Fundamental Aspects of Plant Cell, Tissue, and Organ Culture, Springer Verlag Berlin, Heidelberg, 1977

Course Articulation Matrix

Course Outcome Statements		Programme Outcomes (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	acquire knowledge and skills on plant tissue culture techniques	3	2	1	-	-	-	-	2	2	1	-	2
CO2	acquire knowledge on plant genetic engineering, molecular markers and transgenic regulations through case studies	3	2	1	-	-	-	-	3	-	-	-	2
CO3	develop creative thinking abilities in problem solving	-	2	2	1	2	-	-	2	-	-	-	2
CO4	become proficient in aseptic techniques	3	1	1	2	3	-	2	1	2	-	-	2
Overall CO		3	1	2	2	2	-	1	2	1	-	-	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5012 MOLECULAR PATHOGENESIS OF INFECTIOUS DISEASES L T P C
3 0 0 3

OBJECTIVES

The course aims to

- learn about advanced information on molecular pathogenesis of infectious diseases
- learn about the molecular mechanism of molecular pathogenes

UNIT I INTRODUCTION 5

Discovery of microscope, Molecular Koch's postulates, Concepts of disease, Virulence, Pathogenic cycle, Vaccines and its historical perspective, Biofilms, quorum sensing, multidrug resistance.

UNIT II HOST DEFENSE AGAINST PATHOGENS AND BACTERIAL DEFENSE STRATEGIES 10

Skin, mucosa, cilia secretions, physical movements, physical and chemical barriers to bacterial colonisation, Mechanism of killing by humoral and cellular defenses, Complement, Inflammatory process, Phagocytosis, Colonization, Adherence, Iron acquisition mechanisms, Bacterial defense strategies.

UNIT III MOLECULAR MECHANISMS OF VIRULENCE 8

Virulence, Colonization factors, Microbial toxins, Secretion systems: General secretory pathway, Two-step secretion, Contact dependent secretion, Conjugal transfer system and Autotransporters.

UNIT IV MECHANISMS UNDERLYING MOLECULAR PATHOGENESIS (COMMON ENTERIC PATHOGENS) 12

Shigella: Entry, Induction of macropinocytosis, Invasion of epithelial cells, Intracellular motility and spread, Apoptotic killing of macrophages, Virulence factors involved. *E.coli*: Enterotoxigenic *E.coli* (ETEC), labile & stable toxins, Entero-pathogenic *E.coli* (EPEC), type III secretion, Cytoskeletal changes, intimate attachment; *Enterohaemerrohogic E.coli* (EHEC), Mechanism of bloody diarrhea and Hemolytic Uremic Syndrome, Enteroaggregative *E.coli* (EAEC). *Vibrio Cholerae*: Cholera toxin, Co-regulated pili, filamentous phage, survival.

UNIT V MECHANISMS UNDERLYING MOLECULAR PATHOGENESIS (COMMON NON-ENTERIC PATHOGENS) 10

Mycobacterium tuberculosis: The Mycobacterial cell envelope, Route of entry, Uptake by macrophages, Latency and persistence, Entry into and survival in phagocytes, Immune response against MTB, MTB virulence factors, Emergence of resistance. Influenza virus: Intracellular stages, Neuraminidase and Haemagglutinin in entry, M1 & M2 proteins in assembly and disassembly, action of amantadine. Plasmodium: Lifecycle, erythrocyte stages, transport mechanism and processes to support the rapidly growing schizont, parastiparous vacuoles and knob protein transport, Antimalarials based on transport processes.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 obtain the knowledge on the interaction of host and the pathogens.
CO2 know about evasion strategies of pathogen against host defense
CO3 understand, how to develop the preventive measures and probable treatment strategies for infectious diseases.

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REFERENCES

1. Salyers, Abigail A. “Bacterial Pathogenesis: A Molecular Approach”, 3rd ed., 2010
2. Groisman, “Principles of Bacterial Pathogenesis”, 2001
3. Waksman, Gabriel and Michael caparon “Structural Biology of Bacterial Pathogenesis”, 2005
4. Williams, Peter “Bacterial Pathogenesis” (Methods in Microbiology), 1998
5. Mc Clane, Bruce A. “Microbial Pathogenesis”, 1999
6. Madigan, Michael T. “Biology of Microorganisms”, 15th ed., 2017
7. Stanley, “Genetic analysis of Pathogenic Bacteria”, 1996
8. Hacker, Jorg “Molecular Infection Biology”, 2002

Course Articulation Matrix

Course Outcomes Statement		**Programme Outcomes (PO)**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	obtain the knowledge on the interaction of host and the pathogens.	-	3	2	2	2	-	-	-	2	-	-	2
CO2	know about evasion strategies of pathogen against host defense	-	3	2	2	2	-	-	-	2	-	-	2
CO3	understand, how to develop the preventive measures and probable treatment strategies for infectious diseases.	-	3	2	2	2	-	-	-	2	-	-	2
Overall CO		-	3	2	2	2	-	-	-	2	-	-	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

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BT5013 COMPUTATIONAL FLUID DYNAMICS LT P C
3 0 0 3

OBJECTIVES

The course aims to

- perform time-accurate computations of two-dimensional incompressible flows using vortex particles
- accelerate two dimensional solvers using time-marching schemes employing a new multi-grid scheme.
- develop high resolution codes that work without fine tuning for a large range of Mach numbers.

UNIT I FLUID DYNAMICS 5

Introduction, Reasons for CFD. Typical examples of CFD codes and their use. Validation strategies. Derivation of Governing Equations of Fluid Dynamics: Mass conservation and divergence, Navier-Stokes and Euler equations. Energy equations. Conservation formulation and finite volume discretisation. Partial differential equations: classification, characteristic form. PDEs in science and engineering.

UNIT II BASIC NUMERICS 10

Mathematical behavior of hyperbolic, parabolic and elliptic equations. Well posedness. Discretization by finite differences. Analysis of discretized equations; order of accuracy, convergence. and stability (von Neumann analysis). Numerical methods for model equations related to different levels of approximation of Navier Stokes equation: linear wave equation, Burgers equation, convection-diffusion equation. First and second order numerical methods such as upwind, Lax-Friedrichs, Lax-Wendroff, MacCormack, etc. Modified equation - dissipation and dispersion.

UNIT III COMPRESSIBLE FLOW 10

Euler equations, conservative/non-conservative form. thermodynamics of compressible flow, scalar conservations laws: Conservation, weak solutions, non-uniqueness, entropy conditions. Shock formation, Rankine-Hugoniot relations. Numerical methods for scalar conservation laws. Properties of the numerical scheme such as CFL-condition, conservation and TVD. First order methods. System of conservations laws. Numerical methods for Euler equations: MacCormack and artificial viscosity for non-linear systems. Numerical/physical boundary conditions. Shock tube problem. High resolution schemes for conservations laws. Numerical methods for Euler equations. Boundary conditions, Riemann invariants. Compressible flow in 2D. Numerical methods for Euler equations, cont. Grids, algebraic mesh generation by transfinite inter-polation. Flow around an airfoil.

UNIT IV FINITE VOLUME AND FINITE DIFFERENCE METHODS 10

Laplace equation on arbitrary grids, equivalence with finite-differences, linear systems: Gauss-Seidel as smothers for multi-grid. Staggered grid/volume formulation + BC. Unsteady equations: projection and MAC method, discrete Poisson pressure equation. Time step restrictions. Steady equations: distributive iteration and SIMPLE methods.

UNIT V FINITE ELEMENTS 10

Diffusion problem. Variational form of the equation, weak solutions, essential and natural boundary condition. Finite-element approximations, stability and accuracy, the algebraic problem, matrix assembly. Navier–Stokes equations. Mixed variational form, Galerkin and FE approximations, the algebraic problem. Stability, the LBB condition, mass conservation.

TOTAL :45 PERIODS

OUTCOMES:

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

CO 1 acquire knowledge in fluid dynamics and numeric methods to study the characteristic flow of fluids

CO 2 get in-depth knowledge in computational analysis of different flow patterns

CO 3 acquire stability and accuracy in designing fluid flow systems

TEXTBOOKS / REFERENCES

1. Randall J LeVeque, Finite Volume Method for Hyperbolic Problems, Cambridge University Press, 2002.
2. K.A. Hoffman and S. Chiang, Computational fluid dynamics for scientists and engineers, engineering education system. 2nd edition 1993.
3. J.C. Tannehill, D.A. Anderson, R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, CRC Press, 3rd Edition, 2011.

Course Articulation Matrix

Course Outcome Statements		Programme Outcome (PO)											
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	acquire knowledge in fluid dynamics and numeric methods to study the characteristic flow of fluids	2	1	2	1	-	-	-	1	1	-	-	1
CO2	get in-depth knowledge in computational analysis of different flow patterns	3	2	1	3	1	-	-	-	1	-	1	1
CO3	get stability and accuracy in designing fluid flow systems	1	2	3	3	2	2	-	-	-	1	2	1
Overall CO		2	2	2	3	1	-	-	-	1	-	1	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

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BT5014 COMPUTATIONAL TECHNIQUES IN BIOPROCESS L T P C
2 0 2 3

OBJECTIVES

The course aims to

- make the students to aware about plant designing.
- assess cost and capital investment in product development.
- provide good manufacturing practices

UNIT I INTRODUCTION TO COMPUTATIONAL TOOLS 12

Computation and Error Analysis. Linear Systems and Equations: Matrix representation; Cramer's rule; Gauss Elimination; Matrix Inversion; LU Decomposition; Iterative Methods; Relaxation Methods; Eigen Values.

UNIT II BRACKETING METHODS AND CURVE FITTING 12

Bracketing methods: Bisection, Reguli-Falsi; Open methods: Secant, Fixed point iteration, Newton-Raphson; Multivariate Newton's method. Regression and Curve Fitting, Linear regression; Least squares; Total Least Squares; Interpolation; Newton's Difference Formulae; Cubic Splines.

UNIT III NUMERICAL METHODS 12

Numerical differentiation, higher order formulae. Integration and Integral Equations, Trapezoidal rules; Simpson's rules; Quadrature.

UNIT IV ORDINARY DIFFERENTIAL EQUATIONS 12

ODEs: Initial Value Problems - Euler's methods; Runge-Kutta methods; Predictor-corrector methods; Adaptive step size; Stiff ODEs.

UNIT V PARTIAL DIFFERENTIAL EQUATIONS 12

Boundary Value Problems- Shooting method; Finite differences; Over/Under Relaxation (SOR).PDEs: Introduction to Partial Differential Equations.

Note:

In practical MATLAB will be used and applications of these computational techniques in bioprocess starting from simple enzyme kinetics to parameter estimation in bioprocess modelling will be given as examples

TOTAL: 60 PERIODS

OUTCOMES:

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

CO 1 learn the fundamentals of computational tools in bioprocess
CO 2 fit their experimental data in various numerical models
CO 3 design the experiments based on predictions and corrections

REFERENCES

1. Maria do Carmo Nicoletti and Lakhmi C. Jain,Computational Intelligence Techniques for Bioprocess Modelling, Supervision and ControlStudies in Computational Intelligence, Springer; 2009 edition.
2. Lei Zhi Chen, Sing KiongNguang, and Xiao Dong Chen, Modelling and Optimization of Biotechnological Processes, Springer-Verlag Berlin and Heidelberg GmbH & Co. KG, 1st Edition, 2006.
3. Ravindra Pogaku, Awang Bono, and Christopher Chu, Developments in Sustainable Chemical and Bioprocess Technology, Springer1stedition, 2013.

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Course Articulation Matrix

Course Outcome	Statements	Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	learn the fundamentals of computational tools in bioprocess	1	2	2	1	1	-	-	-	1	2	-	1
CO2	fit their experimental data in various numerical models	3	2	1	2	1	-	-	-	2	2	1	1
CO3	design the experiments based on predictions and corrections	2	1	2	2	1	1	-	-	-	1	2	1
Overall CO		2	2	2	2	1	-	-	-	1	2	1	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

BT5015 PLANT DESIGN AND PRACTICE LT P C
3 0 0 3

OBJECTIVES

The course aims to

- make aware about plant designing.
- understand to assess cost and capital investment in product development.
- follow good manufacturing practices

UNIT I PLANT DESIGN 12

Fermentor design, vessels for Biotechnology, piping and valves for biotechnology, Pressure relief system. Materials of construction and properties. Utilities for plant and their design introduction

UNIT II PROCESS ECONOMICS 8

General fermentation process economics, materials usage and cost, capital investment estimate, production cost estimate. Two case studies – one traditional product and one recombinant product.

UNIT III PHARMACEUTICAL WATER SYSTEM 7

Grades of water, sanitary design, water treatment system, Water distribution system, validation

UNIT IV VALIDATION OF BIOPHARMACEUTICAL FACILITIES 8

Introduction, why validation, when does validation occur, validation structure, resources for validation, validation of systems and processes including SIP and CIP

UNIT V GOOD MANUFACTURING PRACTICES 10

Structure – quality management, personnel, premises and equipment, documentation, production, quality control, contract manufacturing and analysis, complaints and product recall, self inspection. GLP and its principles.

TOTAL :45 PERIODS

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OUTCOMES:

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

CO1 understand design, materials for constructions, and different parts used in the bioreactor.

CO2 estimate the cost and capital investment required for the development of natural and recombinant products

CO3 understand validation of a biopharmaceutical manufacturing facilities.

CO4 learn goods manufacturing facilities.

REFERENCES

1. Peter, Max S. and Timmerhaus, Klaus D. Plant Design and Economics for Chemical Engineers, 4th ed., McGraw Hill, 1991.
2. A compendium of Good Practices in Biotechnology, BIOTOL Series, Butterworth-Heiemann, 1993
3. Seiler, Jiing P. Good Laboratory Practice: The why and How? Springer, 2001
4. Lydersen, B.K. et al., Bioprocess Engineering: Systems, equipment and facilities, John-Wiley, 1994

Course Articulation Matrix

Course Outcome Statements		**Programme Outcomes (PO)**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	Understand design, materials for constructions, and different parts used in the bioreactor.	3	2	3	2	-	-	-	-	3	-	-	2
CO2	estimate the cost and capital investment required for the development of natural and recombinant products	3	2	2	2	-	-	-	-	1	-	3	2
CO3	understand validation of a biopharmaceutical manufacturing facilities.	3	3	2	1	1	1	-	-	1	-	1	2
CO4	learn goods manufacturing facilities.	3	-	-	2	1	2	2	-	1	-	2	2
Overall CO		3	2	2	2	1	1	1	-	2	1	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

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BT5016 GMP AND VALIDATION IN BIOPROCESS INDUSTRIES L T P C
3 0 0 3

OBJECTIVES

The course aims to

- be aware of current validation practice across the bioprocess industry
- assess new process concepts and understand regulatory acceptability for bioprocess industries
- provide knowledge to determine the information required and validate a process

UNIT I TRENDS FOR VALIDATING BIOLOGICAL PROCESSES 9

Importance of process validation for manufacturing drugs and medical devices, Definitions, Process validation, Prospective Validation, Concurrent Validation, Retrospective Validation, Critical Process Parameters, Critical Quality Attributes, Scaled-down model, Worst-case, FDA Guidelines

UNIT II PROCESS VALIDATION: GENERAL PRINCIPLES AND PRACTICES 9

General Considerations for Process Validation, Concept of Bioprocess in Bulk Drug Manufacturing, Concept of Biotechniques in industrial validation, Integration of various biotechniques to maintain quality in downstream processing, CGMP regulations for validating biopharmaceutical (drug) manufacturing.

UNIT III GOOD MANUFACTURING PRACTICE FOR BIOPROCESS ENGINEERING 9

Statutory and regulatory requirements for process validation, Production Methods and Considerations, Automation and control issues, System functionality, Principles for Layout of Bulk Production Facilities, Green Field Development, Brown Field Development, cross-contamination from other sources and linked systems, Clean In Place techniques, interactions with shared systems

UNIT IV APPROACH TO PROCESS VALIDATION 9

Process Design, Process Qualification, Continued Process Verification, attributes relating to identity, strength, quality, purity, and potency; Information and data organization from laboratory-, pilot-, and/or commercial-scale studies, validation of computerized systems.

UNIT V CASES STUDIES IN PROCESS VALIDATION 9

Process validation for recombinant therapeutic proteins like erythropetin, insulin, GMCSF, viral, bacterial vaccines

TOTAL :45 PERIODS

OUTCOMES:

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

CO1 understand the implications of validation for process development
CO2 understand the general principles and practices of process validation of biopharmaceutical manufacturing processes.
CO3 understand manufacturing practice for bioprocess engineering
CO4 learn design, verify and validate process using case studies.

REFERENCES:

1. Process Validation in Manufacturing of Biopharmaceuticals, Third Edition, Anurag S. Rathore, Gail Sofer, CRC Press, 2012
2. Encyclopedia of Industrial Biotechnology: Bioprocess, Bioseparation, and Cell Technology, 1st ed., 2010

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Course Articulation Matrix

Course Outcome Statements		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	understand the implications of validation for process development	3	1	1	2	-	-	-	-	-	-	-	1
CO2	understand the general principles and practices of process validation of biopharmaceutical manufacturing processes.	3	2	2	2	1	-	-	-	1	-	2	2
CO3	understand manufacturing practice for bioprocess engineering	3	-	1	1	2	-	-	1	1	-	2	2
CO4	learn design, verify and validate process using case studies.	3	3	3	2	1	-	-	1	1	-	2	2
Overall CO		3	2	2	2	1	-	-	1	1	1	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

BT5017 HUMAN HEREDITY AND GENETICS L T P C
3 0 0 3

OBJECTIVES

The course aims to

- be aware of the fundamental aspects of human heredity
- make them understand the factors which influence the inheritance
- make them familiar with the tools available to test the inheritance of congenital diseases and gene therapy

UNIT I BACKGROUND, HISTORY AND HEREDITY 9

Introduction to Genetics, Mendelian Genetics. Definitions- Alleles, Phenotypes, Genotypes, Dominance, Incomplete Dominance, co-dominance, Recessiveness, Homozygous, Heterozygous, Hemizygous , Penetrance and Expressivity. Multiple Alleles, ABO blood groups, Bombay phenotype, Epistasis, Pleitropy. Mendelian inheritance in Humans – Segregation and Independent. Assortment – Marfan Syndrome, Porphyria variegate. Prader – Willi Syndrome and Angelman Syndrome. Types of inheritance, Autosomal Recessive, Autosomal Dominant, Sex-linked Dominant and Sex-linked Recessive. Pedigree Analysis of the different types of inheritance.

UNIT II CYTOGENETICS 9

Human chromosome set. Analyzing chromosomes and Karyotype. Making a karyotype and obtaining cells. Aminocentesis, chorionic villi sampling-Variation in chromosome number of sets. Polyploidy, Aneuploidy, Autosomal Monosomy, Autosomal trisomy. Risks for autosomal trisomy. Aneuploidy of the sex chromosomes. Turner syndrome, Kleinfelter Syndrome, XYY. Structural Alterations –Deletions and translocations, Fragility and Uniparental Disomy.

UINIT III DEVELOPMENT AND SEX DETERMINATION 9

Sex determination in humans. Human development: Fertilization to Birth. Trimester of Birth. Teratogens, Radiation, Infections agents and Chemicals. Fatal Alcohol Syndrome. Controlling Reproduction, Contraception and Assisted Reproductive Technologies. Role of environment and chromosomes. Role of Hormones, Androgen insensitivity, Sex testing in sports, Sex phenotype changing and Sex phenotype at puberty. Mutations. Equalizing chromosomes in males and females. Mosaicism, X-inactivation, Expression genes on the X-chromosome. Sex-influenced and Sex-limited traits in humans. Mitochondrial inheritance.

UNIT IV POLYGENES AND MULTIFACTORIAL INHERITANCE 9

Polygenes and Variations in phenotype. Additive model. Averaging out the phenotype for polygenic inheritance. Multifactorial inheritance and traits. Effect of the environment. Threshold effect and the expression of multifactorial traits. Interaction between genotype and the environment. Fingerprints to estimate heritability, Twins, homo zygotic and Dizygotic. Skin color, Cardiovascular diseases-Genetics and Environment. Intelligence and IQ. Searching for genes for intelligence. IQ and Race.

UNIT V GENE MAPPING, TESTING AND BIOETHICS 9

Gene mapping, Testing, Physical mapping, Heteromorphisms, Deletions, Translocation, Dosage mapping. In-situ Hybridization, Somatic Cell hybridization, and positional cloning. Genetic testing and Gene therapy. Clinical Genetics and Genetic counseling. Eugenics and Bioethics.

TOTAL :45 PERIODS

OUTCOMES:

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

CO1 be aware of the fundamental aspects of human heredity

CO2 understand the factors which influence the inheritance

CO3 familiar with the tools available to test the inheritance of congenital diseases and gene therapy

REFERENCES

1. Tamarin, R.H., "Principles of Genetics", Tata McGraw Hill, New Delhi, 2002
2. De Robertis, E. D. P. and De Robertis, E. M. F., "Cell and Molecular Biology", 8th Edition, Lippincott Williams & Wilkins, New York, USA, 2001.
3. Gardner, E.J, Simmons, M.J, and Snustad, D.P., "Principles of Genetics",8th Edition, John Wiley & Sons, Singapore, 2003.
4. Strickberger, M.W., "Genetics", 3rd Edition, Prentice Hall of India, New Delhi, 2008.
5. Klug, W.S. and Cummings, M.R., "Concepts of Genetics", Pearson Education, New Delhi, 2003.

Course Articulation Matrix

Course Outcome Statement		Programme Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	be aware of the fundamental aspects of human heredity	1	-	-	-	-	1	-	1	-	1	-	3
CO2	understand the factors which influence the inheritance	2	-	-	1	2	-	-	1	2	-	-	3
CO3	familiar with the tools available to test the inheritance of congenital diseases and gene therapy	2	-	-	1	3	-	-	2	1	-	-	3
Overall CO		2	-	-	1	2	1	-	1	1	-	1	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

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BT5018 ADVANCES IN BIOPROCESS TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

The course aims to

- understand the design of Bioreactors and to model & design various fermentation processes
- provide knowledge about various fermentation products

UNIT I BLACK BOX MODEL 9

Yield coefficients, black box stoichiometries, elemental balances, heat balance, degrees of reduction balances, systematic analysis of black box stoichiometries, identification of gross measurement errors.

UNIT II MODELING OF VARIOUS FERMENTATION PROCESSES 9

Principles of model building for biotechnological processes, unstructured models on the population level, structured models on the cellular level, morphologically structured model, genetically structured models, cybernetic model, modeling of recombinant systems.

UNIT III DESIGN OF FERMENTATION PROCESSES 9

Kinetics of substrate utilization, biomass growth and product formation, inhibition on cell growth and product formation. Design and operation of continuous cultures, chemostat in series, batch and fed batch cultures, total cell retention cultivation.

UNIT IV BIOREACTOR DESIGN & CONSTRUCTION 9

Basic design and construction of CSTR, bioreactor design of agitator/agitator motor, power consumption in aerated bioreactor, design of sparger, mixing time estimation, oxygen mass transfer capability in bioreactor, Removal of Heat in bioreactor, Main parameters to be monitored and controlled in fermentation processes.

UNIT V CASE STUDIES IN FERMENTATION DERIVED PRODUCTS 9

Case studies on Production of green chemicals, algal biofuels, recombinant Insulin. Case studies should deal with medium design, reactor design & process optimization etc.

TOTAL :45 PERIODS

OUTCOMES:

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

CO1 understand the elemental balances and stoichiometries using black box model

CO2 obtain in depth idea on the design of the fermentation process and construction of bioreactors

CO3 get an overview on the strategies available for production of fermentation derived products

REFERENCES

1. Shuler, M.L. and Kargi, F. Bioprocess Engineering : Basic concepts, 2nd ed., Prentice-Hall, 2002.
2. Doran Pauline M, Bioprocess Engineering Principles, Academic Press, 1995
3. Nielsen, J. and Villadsen, J. “Bioreaction Engineering Principles”. Springer, 2007.
4. Blanch, H.W and Clark D.S., “Biochemical Engineering”, Marcel Dekker,1997
5. Bailey, J.E. and Ollis, D.F. Biochemical Engineering Fundamentals", 2nd ed.,McGraw Hill 1986.
6. Stanbury, P.F., Stephen J. Hall & A. Whitaker, Principles of Fermentation Technology, Science & Technology Books, 3rd ed., 2016

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Course Articulation Matrix

Course Outcome Statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	understand the elemental balances and stoichiometries using black box model	2	3	3	3	-	2	2	-	-	-	-	3
CO2	obtain in depth idea on the design of the fermentation process and construction of bioreactors	2	3	3	2	-	-	-	-	-	-	-	3
CO3	get an overview on the strategies available for production of fermentation derived products	3	2	3	3	-	2	3	-	-	-	-	3
Overall CO		2	3	3	3	-	2	2	-	-	-	-	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

BC5071 **STRUCTURAL BIOLOGY** **L T P C**
2 0 2 3

OBJECTIVES

The course aims to

- familiarize about the structural aspects of protein and DNA
- understand about biophysical techniques for structure determination
- learn about X-Ray Crystallography, NMR and cryoelectron microscopy

UNIT I STRUCTURE OF MACROMOLECULES - DNA 12

Scope of structural biology – implications, drug discovery, Principles of nucleic acid structure - Watson and Crick's base-pairings and their implications. Non Watson and Crick pairing schemes - base stacking interactions - DNA polymorphism - structure of A-DNA, B-DNA and Z-DNA - helical transitions. Non-uniform helical DNA Structure. Unusual DNA structures - hairpins, bulges, cruciform, triplexes, tetraplexes

UNIT II PROTEIN STRUCTURE AND FUNCTION 12

Fundamentals of protein structure, Structural Hierarchy, Motifs and domains: domain structures, Types of proteins, Complex proteins, methods to secondary structural elements and prediction, study of prototype protein under each category - alpha, beta, alpha-beta structures, lysozyme, immunoglobulins, thioredoxin, transferases, membrane proteins, structure of viruses; engineering and design of protein structures.

UNIT III X-RAY CRYSTALLOGRAPHY 12

Elementary crystallography: Introduction: symmetry in crystals, lattices and unit cells, crystal systems, Bravais lattices, Elements of symmetry, Symmetry operation: classes of symmetry operations, space groups concepts. X-ray diffraction - Bragg's law - reciprocal lattice and its application to geometrical Crystallography.

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UNIT IV MODEL BUILDING AND REFINEMENT 12

X-ray scattering: Concept of resolution, Atomic scattering factor - diffraction by a space lattice - structure factor equation - electron density and Fourier Transform, solving phases, model building and refinement, R-factors, B-factor, ccp4 suite, and structure viewers. **Tutorial/Lab exercises –** Demonstration and practice of growing protein crystals (lysozyme, Thaumatin etc.,) by hanging drop and vapor diffusion methods, analysis of diffraction data and structure solution, exercise on refinement and model validation

UNIT V NMR AND CRYO-ELECTRON MICROSCOPY 12

Principle of Nuclear Magnetic Resonance - advantages, Nuclear spin, NMR sensitivity, shielding and deshielding effects, Nuclear Overhauser effect (NOE). Spectral parameters: chemical shift, spin-spin splitting, coupling, spin-spin splitting, proton spin decoupling, 1D- NMR spectra, 2D-
NMR spectroscopy, Introduction to the principles of cryo-electron microscopy.

TOTAL :60 PERIODS

OUTCOMES:

At the end of the course the student will be able to

CO 1 learn structural and functional aspects of protein and DNA
CO 2 understand biophysical techniques
CO 3 understand principles of macromolecular structure determination

REFERENCES

1 K.P. Murphy. Protein structure, stability and folding (2001) Humana press. ISBN 0-89603682-0
2 Arthur M .Lesk Introduction to protein architecture (2010) Oxford University Press. ISBN 0198504748
3 A.McPherson, Introduction to Macromolecular Crystallography. 2nd edition (2016)., John Wiley Co.
4 Carl Branden and John Tooze and Carl Brandon Introduction to Protein Structure, (1999) John Garland, Publication Inc. ISBN 0815323050
5 N. Gautham Bioinformatics (2006) Narosa publications. ISBN-13: 9781842653005
6 Vasantha Pattabhai and N. Gautham Biophysics (2002) Narosa Publishers ISBN 1-4020-0218-1
7 George H. Stout, Lyle H. Jensen, X-Ray Structure Determination: A Practical Guide, 2nd Edition. ISBN 0471607118. 2007
8 G. E. Schulz. Principles of Protein Structure. Springer 2013
9 Rick NG, Wiley Blackwell. Drugs: From discovery to approval 3rd edition (2015)
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11 Crystallography Made Crystal Clear: A Guide for Users of Macromolecular Models, 2006 by Gale Rhodes, Academic Press; 3 edition, ISBN-10: 0125870736, ISBN-13: 978-0125870733
12 The Nuclear Overhauser Effect in Structural and Conformational Analysis, by David Neuhaus Wiley-VCH; 2 edition, 2000, ISBN-10: 0471246751, ISBN-13: 978-0471246756
13 Single-particle Cryo-electron Microscopy: The Path Toward Atomic Resolution/ Selected Papers Of Joachim Frank With Commentaries, World Scientific Publishing Co Pte Ltd, 2018

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Course Articulation Matrix:

Course Outcome Statements		Program Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	learn Structural and functional aspects of protein and DNA	3	3	3	2	3	–	–	–	–	–	–	–
CO2	understand Biophysical Techniques	3	3	3	2	3	–	–	–	–	–	–	–
CO3	understand principles of macromolecular structure determination	3	3	3	2	3	–	–	–	–	–	–	–
Overall CO		3	3	3	2	3	–	–	–	–	–	–	–

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

BP5072 BIOGENERICS AND BIOPHARMACEUTICALS L T P C
3 0 0 3

OBJECTIVES

The course aims to,

- Introduce the students about biogenerics and biosimilars and their characterization using analytical methods.
- Correlate the conceptual learning of biopharmaceuticals with their therapeutic equivalence using case studies.

UNIT I BIOGENERICS INTRODUCTION 9

Definition: Generics and its advantages; Biogenerics and Biosimilars; Why biosimilars are not (bio) generics; The advent of Biosimilars; The role of patents in the drug industry; Protein-based biopharmaceuticals; Manufacturing processes; Global market; International Non-proprietary Names (INN) nomenclature system biosimilars regulation (EU position, US pathways, Government initiatives)

UNIT II BIOSIMILARS AND ITS SCENARIO 9

Approved follow-on proteins/Biosimilars; Characteristics of high selling peptides and proteins,; Products with expired patents; Challenging originator's patents; Target products for FOB (follow-on biologics) /Biosimilars development peptides; Recombinant Non Glycosylated proteins; Recombinant glycosylated proteins; Industries dealing with biogenerics and its market value; World scenario; Indian scenario.

UNIT III CHARACTERIZATION OF BIOSIMILARS 9

Approaches to the characterization of biosimilars; Problems in characterizing biologics(Types of biologic, Peptides, Non-glycosylated proteins, Glycosylated proteins, Monoclonalantibodies); Equivalence issues; Post-translational modifications; Effect of microheterogeneity; Pharmacokinetics; Pharmacodynamics; and Clinical efficacy; Analytical Methods for the characterization of biosimilars (Chromatography, Protein sequencing, Mass Spectrometry, UV absorption, Circular dichroism, X-ray techniques, Nuclear magnetic resonance, Electrophoresis, Western blotting, Bioassays, ELISA, Immunoprecipitation and other procedures)

UNIT IV IMMUNOGENICITY OF BIOPHARMACEUTICALS 9

uting to immunogenicity (product-related factors and host-related factors), consequence of immunogenicity to biopharmaceuticals; Measurement of immunogenicity.

UNIT V CASE STUDIES 9

Case studies: Erythropoietin, Insulin, Somatotropin, Interleukin-2, Interferon Granulocyte-macrophage-CSF, DNase, Factor VIIa, Factor IX, Factor VIII, Activated protein C, Tissue plasminogen activator, Monoclonal antibodies etc., Immunogenicity of biopharmaceuticals: Immunogenicity; Factors contributing.

TOTAL :45 PERIODS

OUTCOMES:

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

CO1 acquire knowledge about biopharmaceutical production.

CO2 update with the regulatory aspects of biosimilars.

CO3 learn about production and characterization of biopharmaceuticals.

REFERENCES

1. Niazi, Sarfaraz K. “Handbook of Biogeneric Therapeutic Proteins: Regulatory,Manufacturing, Testing, and Patent Issues”. CRC Press, 2006.
2. Ho, Reedney J. Y., MiloGibaldi. “Biotechnology & Biopharmaceuticals TransformingProteins and Genes into Drugs”, 2nd edition, 2013.

Course Articulation Matrix

Course Outcome Statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	acquire knowledge about biopharmaceutical production	1	1	1	-	1	1	1	-	-	-	-	2
CO2	update with the regulatory aspects of biosimilars	1	1	1	-	1	1	1	-	-	-	-	2
CO3	learn about production and characterization of biopharmaceuticals	1	1	1	-	1	1	1	-	-	-	-	2
Overall CO		1	1	1	-	1	1	1	-	-	-	-	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

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BP5073	CLINICAL TRIALS AND BIOETHICS	L T PC
		3 0 03

OBJECTIVES

The course aims to,

- provide fundamental learning about clinical trial management in drug development and project management in clinical trials.
- learn about pharmacovigilance, quality control and ethical management in clinical research.

UNIT I INTRODUCTION TO CLINICAL TRIALS 9

Fundamentals of clinical trials; Basic statistics for clinical trials; Clinical trials in practice;Reporting and reviewing clinical trials; Legislation and good clinical practice - overview of theEuropean directives and legislation governing clinical trials in the 21st century; International perspectives; Principles of the International Committee on Harmonisation (ICH)-GCP.

UNIT II REGULATIONS OF CLINICAL TRIALS 9

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

UNIT III MANAGEMENT AND ETHICS OF CLINICAL TRIALS 9

Project management in clinical trials - principles of project management; Application in clinical trial management; Risk assessment; Research ethics and Bioethics - Principles of research ethics; Ethical issues in clinical trials; Use of humans in Scientific Experiments;Ethical committee system including a historical overview; informed consent; Introduction To ethical codes and conduct; Introduction to animal ethics; Animal rights and use of animals in the advancement of medical technology; Introduction to laws and regulations regarding the use of animals in research.

UNIT IV INFORMED CONSENT 9

Consent and data protection- the principles of informed consent; Consent processes; Data Protection; Legislation and its application; Data management – Introduction to trial master files and essential documents; Data management.

UNIT V QUALITY CONTROL AND GUIDELINES 9

Quality assurance and governance - quality control in clinical trials; Monitoring and audit;Inspections; Pharmacovigilance; Research governance; Trial closure and pitfalls-trial closure; Reporting and legal requirements; Common pitfalls in clinical trial management.

TOTAL : 45 PERIODS

OUTCOMES:

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

CO1 acquire knowledge about the fundamentals, various statistics, practicing and reviewing of clinical trials.

CO2 know about guidelines and regulation of clinical trials of new drugs.

CO3 understand project management in clinical trials and about various ethical issue while conducting clinical trials.

CO4 manage the output data obtained from clinical trials and maintain quality in clinical trials.

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REFERENCES

1. Lee, Chi-Jen; etal., “Clinical Trials or Drugs and Biopharmaceuticals.” CRC / Taylor & Francis, 2011.
2. Matoren, Gary M. “The Clinical Research Process in the Pharmaceutical Industry.”Marcel Dekker, 1984.

Course Articulation Matrix

Course Outcome Statements		Programme Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	acquire knowledge about the fundamentals, various statistics, practicing and reviewing of clinical trials.	2	1	1	-	-	-	-	-	2	-	-	-
CO2	know about guidelines and regulation of clinical trials of new drugs.	2	1	1	-	-	-	-	2	2	-	-	-
CO3	understand project management in clinical trials and about various ethical issue while conducting clinical trials.	2	1	2	-	-	-	-	3	2	-	3	-
CO4	manage the output data obtained from clinical trials and maintain quality in clinical trials.	2	2	2	1	1	-	-	2	2	-	-	-
Overall CO		2	1	2	1	1	-	-	2	2	-	1	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

BP5074 MOLECULAR MEDICINE AND MECHANISM L T P C
3 0 0 3

OBJECTIVES

The course aims to,

- understand the molecular mechanism of the disease and advanced understanding of drug interactions.
- learn the molecular organisation of different organ systems and its functions.

UNIT I INTRODUCTION TO MOLECULAR MEDICINE 9

Organization of the Human Genome, Chromosomes and Genes – Recombinant DNA and Genetic Techniques – Transcriptional Control of Gene Expression – transmission of Human

Genetic Disease –Human Genome Project – Cell Cycle Oncogenes and Tumor suppressor Genes – Molecular Diagnostic Testing – Genetic Counseling – Transgenic Mice as Models of Disease, Introduction to gene therapy.

UNIT II CARDIOLOGY 9

Molecular Cardiology Congenital Heart Disease–Inherited Cardiomyopathies–Coronary Atherosclerosis – Endothelium – Derived Nitric Oxide and Control of Vascular Tone – Hypertension – Cardiac Arrhythmias – Cardiovascular Gene Therapy.

UNIT III PULMONOLOGY 9

Asthma – Cystic Fibrosis – Pulmonary Emphysema – Surfactant Deficiency – Lung Cancer: The Role of Tumor Suppressor Genes – Strategies for controlling the diseases.

UNIT IV ENDOCRINOLOGY 9

Mechanisms of Hormone Action – Diabetes Mellitus – Pituitary Function and Neoplasia Hormone Deficiency- Disorders –Thyroid Disorders – Disorders of the parathyroid Gland – Congenital Adrenal Hyperplasia– Adrenal Disease – Multiple Endocrine Neoplasia Type, Mechanisms of Hypoglycemia Associated with increased Insulin Production.

UNIT V NEPHROLOGY 9

Renal Development – Mechanisms of Leukocyte Extravasation – Ischemic Acute Renal Failure – Potassium Secretory Channels in the Kidney – Alport Syndrome – Nephrogenic Diabetes Insipidus – Polycystic Kidney Disease – Renal Neoplasms: Wilms' Tumor and Renal-Cell Carcinoma.

TOTAL:45 PERIODS

OUTCOMES:

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

CO 1 learn about the human genome, molecular diagnostic testing and gene therapy.

CO 2 learn about various physiological systems in the human body and genetic disease associated to them.

CO 3 understand the molecular mechanism of the treatments for these genetic disease.

REFERENCES

1. Jameson, J. L., Francis, S.C., "Principles of Molecular Medicine", Human Press, 1998.
2. Ross, D.W. "Introduction to Molecular Medicine", 3rd Edition, Springer, 2002.
3. Ross, D.W. "Introduction to Oncogenes and Molecular Medicine",Springer, 1998.
4. Pasternak, J.J. "An Introduction to Human Molecular Genetics", 2nd Edition, Wiley Liss, 2005.
5. Strachan, Tom and Andrew P. Read. "Human Molecular Genetics, Bios, 1996.

Course Articulation Matrix

Course Outcome Statements		Programme Outcome (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
CO1	learn about the human genome, molecular diagnostic testing and gene therapy.	3	2	1	-	-	-	-	-	1	-	-	2
CO2	learn about various physiological systems in the human body and genetic disease associated to them.	3	2	1	-	-	-	-	-	1	-	-	2
CO3	Understand the molecular mechanism of the treatments for these genetic diseases.	3	2	1	-	3	-	-	-	1	-	-	2
Overall CO		3	2	1	-	1	-	-	-	1	-	-	2

(1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

BC5072 **SYNTHETIC BIOLOGY** **L T P C**
3 0 0 3

OBJECTIVES

The course aims to

- Familiarize with the concepts of modern DNA assembly techniques to build biological circuits
- Familiarize with the principles of designing biological circuits with control levels

UNIT I SYNTHETIC BIOLOGY – BIOLOGICAL COMPONENTS/CIRCUITS 9

Definition and scope, applications of Synthetic biology and milestones in development, principles of artificial gene synthesis, promoters, ribosomal binding sites (RBS), coding sequences and terminators, Logical operators – Repressilator, Toggle-switch, Mammalian tunable synthetic oscillator, Coupled bacterial oscillator , Bacterial tunable synthetic oscillator, Globally coupled bacterial oscillator

UNIT II ENGINEERING PRINCIPLES IN BIOLOGY 10

Structure and expression and regulation in prokaryotic and eukaryotic systems, Advanced biotechnological methods comprising cloning, mutagenesis, polymerase chain reaction, synthesis of nucleic acids, DNA sequence determination, synthetic genomics, CRISPR-Cas9, directed evolution, alternative splicing and computational modeling. Experimental characterisation of structural and functional properties of biomolecules

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UNIT III NUMERICAL METHODS FOR SYSTEMS ANALYSIS AND DESIGN 8

Fundamental on the theoretical and computational modelling of replicating systems, Bioinformatic analysis and characterisation of genes and biomolecules, Mathematical model of processes for metabolic pathways and genetic regulatory circuits, Parameter estimation in biochemical pathways, optimal experimental design, dynamic optimization of biosystems

UNIT IV FABRICATION OF GENETIC SYSTEMS 9

Introduction to BioBricks and standardization, assembly methods, induction and addition of measurable element, (Eg. GFP) to an existing natural biological circuit, overview and scope of GenoCAD, Clotho framework.

UNIT V CASE STUDIES IN ENGINEERED SYSTEMS 9

RNA-based regulatory system for independent control of transcription activities of multiple targets, Applications of Engineered Synthetic Ecosystems, pT181 antisense-RNA-mediated transcription attenuation mechanism and applications, Ethics and patentability,.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of this course Students will be able to

CO1 Describe how the regulation of the genes and properties of gene products can be altered with synthetic biology methods

CO2 Apply a scientific approach to the planning and overview of executing replicating systems with new properties that can be regulated

CO3 Critically analyse the results and generate testable hypotheses for synthetic biology experiments

REFERENCES

1. Synthetic Biology: Tools and Applications by Huimin Zhao, Academic Press; 1 edition (2013), ISBN-10: 0123944309, ISBN-13: 978-0123944306
2. Bioengineering: A Conceptual Approach by Mirjana Pavlovic, Springer; 2015 edition, ISBN-10: 3319107976, ISBN-13: 978-3319107974
3. Biological Modeling and Simulation: A Survey of Practical Models, Algorithms, and Numerical Methods (Computational Molecular Biology) by Russell Schwartz, The MIT Press; 1 edition (2008)

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Course Articulation Matrix:

Course Outcome Statements		Program Outcome (PO)											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	Describe how the regulation of the genes and properties of gene products can be altered with synthetic biology methods	2	3	3	2	3	–	–	–	–	–	–	1
CO2	Apply a scientific approach to the planning and overview of executing replicating systems with new properties that can be regulated	2	3	3	3	3	–	–	–	–	–	–	1
CO3	Critically analyse the results and generate testable hypotheses for synthetic biology experiments	2	3	3	3	3	–	–	–	–	–	–	1
Overall CO		2	3	3	3	3	–	–	–	–	–	–	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

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OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop– RDBMS versus Hadoop–Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop– Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

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REFERENCES:

1. VigneshPrajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, UmeshaNayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

OE5092 **INDUSTRIAL SAFETY** **LT P C**
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

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 II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

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 III WEAR AND CORROSION AND THEIR PREVENTION 9

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 IV FAULT TRACING 9

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 V PERIODIC AND PREVENTIVE MAINTENANCE 9

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

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook,Eighth Edition,2008

OE5093 OPERATIONS RESEARCH LT P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method, Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENTOF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING CONCEPTS 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

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UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

OUTCOMES

CO1 – Understand the costing concepts and their role in decision making CO2– Understand the project management concepts and their various aspects in selection
CO3–Interpret costing concepts with project execution
CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 COMPOSITE MATERIALS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identifythe various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

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UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, WestGermany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

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OE5096 **WASTE TO ENERGY** **L T P C**
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITIIBIOMASS PYROLYSIS 9

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

UNITIII BIOMASS GASIFICATION 9

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.

UNITIV BIOMASS COMBUSTION 9

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.

UNITV BIO ENERGY 9

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.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

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REFERENCES:

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

AUDIT COURSES (AC)

AX5091 ENGLISHFOR RESEARCHPAPERWRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNITI INTRODUCTION TO RESEARCH PAPER WRITING 6

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

UNIT II PRESENTATION SKILLS 6

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

UNIT III TITLE WRITING SKILLS 6

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, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

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

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 –Learn about what to write in each section
CO3 –Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

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

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AX5092	DISASTER MANAGEMENT	L T P C 2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

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

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

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 III DISASTER PRONE AREAS IN INDIA 6

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 IV DISASTER PREPAREDNESS AND MANAGEMENT 6

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 V RISK ASSESSMENT 6

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

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster

CO2: Ability to explain critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

CO5: Ability to develop the strengths and weaknesses of disaster management approaches

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. Nishitha Rai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company,2007.
3. Sahni, Pardeep Et.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094 **VALUE EDUCATION** **L T P C**

2 0 0 0

OBJECTIVES

Students will be able to

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

UNIT I

Values and self-development–Social values and individual attitudes. Workethics,Indianvisionofhumanism.Moralandnon-moralvaluation.Standards and principles. Value judgements

UNIT II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love fornature, Discipline

UNIT III

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.

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

UNIT IV

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.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the over all personality.

Suggested reading

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

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AX5095	CONSTITUTION OF INDIA	L T P C 2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- 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 nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:

History, Drafting Committee, (Composition &Working)

UNIT II PHILOSOPHYOFTHE INDIANCONSTITUTION:

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND 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 IV 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 V LOCAL ADMINISTRATION:

District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION:

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- DiscussthegrowthofthedemandforcivilrightsinIndiaforthebulkofIndiansbeforethe arrival of Gandhi in Indian politics.
- Discusstheintellectualoriginsoftheframeworkofargumentthatinformedtheconceptualization
- of social reform sliding to revolution in India.
- DiscussthecircumstancessurroundingthefoundationoftheCongressSocialistParty[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- DiscussthepassageoftheHinduCodeBillof1956.

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Suggested reading

1. TheConstitutionofIndia,1950(BareAct), Government Publication.
2. Dr. S. N. Busi, Dr. B. R.AmbedkarframingofIndianConstitution,1st Edition,2015.
3. M.P. Jain,IndianConstitutionLaw,7th Edn.,Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis,2015.

AX5096	PEDAGOGY STUDIES	L	T	P	C
		2	0	0	0

OBJECTIVES

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY:

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

UNIT II THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III EVIDENCE ON THE EFFECTIVENESS OFPEDAGOGICALPRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT IV PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

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

TOTAL:30 PERIODS

OUTCOMES:

Students will be able to understand:

- Whatpedagogicalpracticesarebeingusedbyteachersinformalandinformalclassrooms in developing countries?
- What is the evidence on the effectiveness soft he sepedagogical practices, in what conditions, and with what population of learners?
- How can teacher education(curriculum and practicum)and the school curriculum and guidance materials best support effective pedagogy?

Suggested reading

1. Ackers, HardmanF(2001)ClassroominteractioninKenyanprimaryschools,Compare,31(2): 245-261.
2. AgrawalM (2004)Curricular reform in schools: The importance of evaluation, JournalofCurriculumStudies,36(3):361-379.
3. AkyeampongK(2003)TeachertraininginGhana-doesitcount?Multi-siteteachereducationresearchproject(MUSTER) country report 1.London:DFID.
4. Akyeampong K,LussierK, PryorJ, WestbrookJ (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. ChavanM (2003) Read India: Amass scale, rapid, ‘learningtoread ’campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

Attested

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AX5097	STRESS MANAGEMENT BY YOGA	L T P C 2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do‘s and Don’t’sin life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTEDREADING

1. ‘YogicAsanasforGroupTarining-Part-I”:JanardanSwamiYogabhyasiMandal, Nagpur
2. “Rajayogaorconquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department),Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To a waken wisdom in students

UNIT I

Neetishatakam-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)

UNIT II

Approach to day to day work and duties - Shrimad BhagwadGeeta: 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.

UNIT III

Statements of basic knowledge - Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 -Personality of role model - shrimadbhagwadgeeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL:30 PERIODS

OUTCOMES:

Students will be able to

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

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.