SCHEME & SYLLABUS OF

VII & VIII SEMESTERS

(160 Credits)

B.E. BIOTECHNOLOGY 2025-26

VISION AND MISSION OF THE DEPARTMENT

VISION:

To be a center of excellence in education and research in Biotechnology to address the global challenges

MISSION:

1. To offer industry relevant curriculum and research through industry collaborations.

2. To continuously upgrade the infrastructure to develop the facilities for training and research.

3. To provide a good learning environment to help students imbibe professional ethics, communication skills, team spirit and societal commitment.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The Program Educational Objectives are as follows:

1. The graduates of the program are practicing engineering profession in IT sectors (IT system engineers, data analyst and computer programmer), and BT sectors (clinical data coordinator, clinical research associate, Quality controller and Quality assurance analyst, Molecular biologist and Business development executive)

2. The graduates of the program are engaged in higher studies leading to professional degree in specific domain such as biological sciences, computational biology and also engaged in life-long learning.

3. The graduates of the program practice profession with high ethical and moral values and have developed good communication skills and leadership qualities while working as a member of the team or as a team leader.

PROGRAM SPECIFIC OUTCOMES (PSOs):

1. Students will be able to conduct the Upstream and Downstream experiments to produce, optimize, separate, purify and characterize biological compounds.

2. Students will be able to solve advanced biological problems with the technical skills of Bioinformatics, Biomolecular simulation, Proteomics and Genomics using computational techniques.

3. Students will be able to analyse Biopharmaceutical challenges of Biological systems by applying the concepts of Biological sciences

PROGRAMME OUTCOMES (POs)

PO1	**Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization respectively to develop to the solution of complex engineering problems.
PO2	**Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development.
PO3	**Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required.
PO4	**Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions.
PO5	**Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems.
PO6	**The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment.
PO7	**Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws
PO8	**Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	**Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	**Life-Long Learning:** Recognize the need for and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change.

SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU

(An autonomous institution affiliated to VTU, Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC with 'A' grade & ISO 9001:2015 Certified)

B.E. in Biotechnology

SCHEME OF TEACHING AND EXAMINATION (NEP-II, batch-1) 2022-2026

VII Semester (Swappable VII and VIII Semester)

Sl. No.	Course and Course Code		Course Title	Teaching / Paper setting Dept.	Teaching hrs./week				Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1.	IPCC	S7BTI01	Bioprocess Control and Automation	BT/CH	28	28	28	50	3	50	50	100	4
2.	IPCC	S7BTI02	Deep learning for Genomics	EC/BT	42	0	28	36	3	50	50	100	4
3.	HSMS	SHS08	Management and Entrepreneurship	BT	42	0	0	48	3	50	50	100	3
4.	PEC	S7BTPE	Professional Elective Course-III	BT	42	0	0	48	3	50	50	100	3
5.	OEC	S7OEXX	Open Elective Course-II	-	42	0	0	48	3	50	50	100	3
6.	PROJ	BTMP	Major Project Phase II	BT	0	0	150	60	3	100	100	200	7
7.	AICTE	AAP	AICTE Activity Points (Applicable for both Regular and Lateral Entry students)	40 hours community service to be documented and produced for the examination									
			Total		**196**	**28**	**206**	**290**		**350**	**350**	**700**	**24**

Note: IPCC: Integrated Professional Core Course, PCC: Professional Core Course; PEC: Professional Elective Course;
OEC: Open Elective Course; PROJ: Project Phase –II;
L: Lecture, T: Tutorial, P: Practical S= SDA: Skill Development Activity, CIE: Continuous Internal Evaluation, SEE: Semester End Evaluation.

Professional Elective Course (PEC) (Offered by the Department)

S7BTPE11	Biopharmaceuticals and Regulatory Affairs	S7BTPE13	Forensic Science Technology
S7BTPE12	Nanobiotechnology	S7BTPE14	Computer Aided Drug Design

Note: VII and VIII semesters of IV years of the program

1) Institutions can swap the VII and VIII Semester Schemes of Teaching and Examinations to accommodate research internships/ industry internships after the VI semester.
2) Credits earned for the courses of VII and VIII Semester Scheme of Teaching and Examinations shall be counted against the corresponding semesters whether the VII or VIII semesters is completed during the beginning of the IV year or the later part of IV years of the program.

Professional Core Course (IPCC): Refers to Professional Core Course Theory Integrated with practical of the same course. Credit for IPCC can be 04 and its Teaching–Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper. For more details, the regulation governing the Degree of Bachelor of Engineering (B.E.)

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B.E. in Biotechnology

SCHEME OF TEACHING AND EXAMINATION (NEP-II, batch-1) 2022-2026

VIII Semester (Swappable VII and VIII Semester)

Sl. No.	Course and Course Code		Course Title	Teaching / Paper setting Dept.	Teaching hrs./week				Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1.	PEC	S8BTPEXX	Professional Elective (Online Courses) *[Details of the scheme will be intimated soon]*	BT	42	0	0	48	3	50	50	100	3
2.	OEC	S8OEXX	Open Elective (Online Courses) *[Details of the scheme will be intimated soon]*	-	42	0	0	48	3	50	50	100	3
3.	INT	INT	Internship (Industry/Research) (14-20 weeks)	BT	0	0	300	0	3	100	100	200	10
			Total		**84**	**0**	**300**	**96**		**200**	**200**	**400**	**16**
		AAP	AICTE Activity Points (Applicable for both Regular and Lateral Entry students)	40 hours community service to be documented and produced for the examination									

Note: **PEC**: Professional Elective Course; **OEC:** Open Elective Course (Online); **INT:** Industry Internship / Research Internship / Rural Internship
L: Lecture, **T**: Tutorial, **P**: Practical **S= SDA**: Skill Development Activity, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Evaluation.

Professional Elective (Online Courses – suggested by BoS, NPTEL courses)

S8BTPE11	Genome editing and engineering	S8BTPE13	Biomedical Instrumentation
S8BTPE12	Drug delivery : principles and engineering	S8BTPE14	Biomass Energy Conversion Technologies

Open Elective (Online Courses – suggested by BoS, NPTEL)

S8OE11	Psychology of Learning	S8OE14	Micro irrigation engineering
S8OE12	Artificial Intelligence in Drug Discovery and Development	S8OE15	Cyber Security
S8OE13	Artificial Intelligence: Search methods for problem solving	S8OE16	Introduction to machine learning

Note: VII and VIII semesters of IV years of the program

1) Institutions can swap the VII and VIII Semester Schemes of Teaching and Examinations to accommodate research internships/ industry internships after the VI semester.
2) Credits earned for the courses of VII and VIII Semester Scheme of Teaching and Examinations shall be counted against the corresponding semesters whether the VII or VIII

BIOPROCESS CONTROL AND AUTOMATION

Contact Hours/ Week:	L:T:P:: 2:2:2	**Credits:**	4
Total Lecture Hours:	28+28	**CIE Marks:**	50
Course Code:	S7BTI01	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Understand the concepts of first order systems and its response for various types of input.
2.	Conceptualize the importance of interacting and Non-interacting systems.
3.	Study the importance various controllers and final control elements.
4.	Understand the concepts of Open loop system and Closed loop system.
5.	Study the various criteria involved in stability of a system and performing stability test.

UNIT I
Introduction: The Laplace transform definition, transforms of simple functions, inversions by partial fractions, initial-value theorem, final value theorem. First order systems: Mercury in glass thermometer, liquid level system, liquid level process with constant flow outlet, Response of first order system for step, pulse, impulse and sinusoidal changes in input, linearization, conceptual numerical
6+6 Hours

UNIT II
First order systems in series: Interacting system, non-interacting systems, generalization of several non-interacting systems in series. Dynamic response to step, pulse and impulse inputs for interacting and non-interacting systems; conceptual numerical. Second order systems: Second order systems with transfer functions (spring-damper, control valve), response of second order system to step, pulse/impulse and sinusoidal input – Over damped, under damped and critically damped condition of second order system, transportation lag
6+6 Hours

UNIT III
Controllers and Final control elements: Block diagram, negative feedback versus positive feedback, development of block diagram, measuring element, final control elements, Actuators, Positioners, Valve body, Valve plugs, Characteristics of final control elements, controllers – two position control, proportional control, derivative control, integral control, P-I (proportional-integral) control, P-D (proportional- derivative) control, P-I-D (proportional-integral-derivative) control, conceptual numerical.
6+6 Hours

UNIT IV
Closed loop control systems: Standard block diagram symbols, overall transfer function for single loop systems, overall transfer function for change in set point, overall transfer function for multiloop control systems, servo and regulatory problems. Transient response of first and

second order processes for set point changes and load changes with proportional and PI controllers, conceptual numerical
5+5 Hours

UNIT V
Controller design and stability: Concept of stability, definition of stability, Criteria for stability, Routh test for stability, routh array, theorems of the routh test concept of Root locus (basics), plotting the root locus diagram, rules for plotting the root locus diagram, Introduction to frequency response, substitution rule, generalization, transportation lag, Bode criteria for stability, gain and phase margins, Conceptual.
5+5 Hours

TEXT BOOKS		
1	Donald R Coughanowr	Process System analysis and Control – 2nd Edition, McGraw Hill, 1991. 0-07-l 00807-l
2	George Stephanopoulos	Chemical Process Control—new edition, Prentice-Hall of India, 2008, 8172484030

REFERENCE BOOKS		
1	Seborg, Edger, Mellichamp, Doyle	Process dynamics and Control, 3rd edition, John Wiley and Sons, 9780470128671, 2016
2	Jonathan Love	Process Automation Handbook, A Guide Theory and Practice, 2007, 978-1-84628-282-9,

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Apply the mathematical concept of Laplace transform to obtain the transfer function of various first order systems like thermometer and liquid level process.
CO2	Describe and develop the transfer functions associated with second order systems for different inputs.
CO3	Describe block diagram and various types of controllers for process control operations.
CO4	Analyze the transient responses for various first and second order systems for set point and load changes.
CO5	Apply different tests to the control systems to interpret the stability.

Course Articulation Matrix

		POs											**PSOs**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO	**CO1**	2	2										2		
	CO2	2	3										2		

	CO3	2	3	1								2		
	CO4	2	3	1								2		
	CO5	2	2											2

BIOPROCESS CONTROL AND AUTOMATION LABORATORY

Contact Hours/ Week:	L:T:P:: 0+0+2	**Credits:**	0
Total Lecture Hours:	28	**CIE Marks:**	50
Course Code:	S7BTI01	**SEE Marks:**	0

Course objectives:	
This course will enable students to:	
1.	Understand the concepts of various types of transducers and working principle.
2.	Understand the dynamics of first order system for various types of input.
3.	Study the importance of interacting and Non-interacting systems for various input types.
4.	Study the importance various controllers and final control elements
5.	Understand the concepts of various controllers in process control.

List of Experiments	
Sl no.	**Experiment**
1	Characteristics of temperature Transducers (Thermocouple)
2	Dynamics of single tank system
3	Characteristics of temperature Transducers (RTD)
4	Dynamics of manometer
5	Dynamics of First order system (mercury thermometer) for step input
6	Non-interacting system responses to step / pulse input.
7	Interacting System responses to step / pulse input
8	Flow control – responses to set point / load change
9	Pressure control – responses to set point / load change
10	Tuning of Flow controller (ZN and CC methods) and responses of tuned P, PI and PID Controllers.
11	Tuning of Pressure controller (ZN and CC methods) and responses of tuned P, PI and PID controllers
12	Effect of ON/OFF, P, PI,PD and PID on pH control

TEXT BOOKS		
1	Donald R Coughanowr	Process System Analysis and Control – 2nd Edition, McGraw Hill, 1991, 9340470128456
2	George Stephanopoulos	Chemical Process Control—New Edition, Prentice-Hall of India,2008, 9234470128435

REFERENCE BOOKS		
1	Seborg, Edger, Mellichamp, Doyle	Process Dynamics and Control, 3rd Edition, John Wiley and Sons, 9780470128671

2	Jonathan Love	Process Automation Handbook, A Guide to Theory and Practice, 978-1-84628-282-9, 2007.

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Interpret the response of various types transducers
CO2	Solve various problems associated with first order system in series.
CO3	Solve various problems associated with first order system in series.
CO4	Choose suitable controllers and final control element for any process control operations (like flow, pressure, pH, Temperature).
CO5	Address the use of closed loop system in controlling any processes using P, PI, PD, PID controllers.

Course Articulation Matrix

		POs											**PSOs**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
COs	**CO1**	**2**	**2**										**2**		
	CO2		**3**										**2**		
	CO3		**3**										**2**		
	CO4		**3**			**2**							**2**		
	CO5		**3**			**2**							**2**		

DEEP LEARNING FOR GENOMICS

Contact Hours/ Week:	L:T:P:: 3:0:2	**Credits:**	4
Total Lecture Hours:	42	**CIE Marks:**	50
Course Code:	S7BTI02	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Understand the fundamentals of genomics and the principles of genomic signal processing.
2.	Explore signal representation and feature extraction techniques in genomic sequences.
3.	Introduce deep learning models and their relevance to genomic data.
4.	Learn deep learning algorithms for classification, prediction, and disease association.
5.	Integrate real-world datasets and evaluate deep learning performance for genomic analysis.

UNIT I
Introduction to Genomics and Genomic Signal Processing: Basics of DNA, RNA, and gene expression, Digital representation of DNA sequences, Introduction to genomic signal processing (GSP), Importance of GSP in biomedical engineering, Overview of tools and databases (NCBI, Ensemble)
8 Hours

UNIT II
Signal Representation and Feature Extraction: Numerical mapping techniques: Voss, EIIP, Z-curve, Quaternion, Fourier, Wavelet, and S-transform for genomic signal analysis, Feature engineering from genomic sequences, Dimensionality reduction: PCA, t-SNE, Data preprocessing pipelines
8 Hours

UNIT III
Fundamentals of Deep Learning for Genomics: Introduction, Anatomy of DNN, DNNs for Genomics, Introduction to CNN, CNNs for Genomics, Different RNN architectures, Application and use cases of RNNs in genomics.
8 Hours

UNIT IV
Applications of Deep Learning in Genomic Data: Promoter and splice site prediction, Gene expression classification, Mutation detection and cancer classification, CRISPR guide RNA efficiency prediction, Integration of multi OMICS data
9 Hours

UNIT V
Case Studies and Performance Evaluation: Case studies using real-world datasets (TCGA, GEO), Performance metrics: accuracy, sensitivity, specificity, AUC, Explainable AI in genomics, Ethical issues and future directions in genomic DL, Challenges and best practices for deep learning in genomics.
9 Hours

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Apply the core concepts of genomics and digital signal processing techniques to digitally represent DNA/RNA sequences in the field of Biomedical Engineering.
CO2	Apply appropriate numerical representations and extract meaningful features from genomic sequences.
CO3	Design and implement deep learning models tailored for genomic sequence analysis.
CO4	Demonstrate the ability to solve real-world genomic problems using deep learning approaches.
CO5	Analyze, evaluate, and interpret results from genomic DL models on real datasets.

Course Articulation Matrix

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	**CO1**	**2**	**1**											**3**	
	CO2	**2**	**1**											**2**	
	CO3	**2**	**1**	**1**										**2**	
	CO4	**2**	**2**	**1**										**2**	
	CO5	**2**	**2**	**1**										**2**	

DEEP LEARNING FOR GENOMICS LABORATORY

Contact Hours/ Week:	L:T:P:: 0:0:2	**Credits:**	0
Total Lecture Hours:	28	**CIE Marks:**	50
Course Code:	S7BTI02	**SEE Marks:**	0

Course objectives: This course will enable students to:	
1.	Understand the fundamentals of genomics and the principles of genomic signal processing.
2.	Explore signal representation and feature extraction techniques in genomic sequences.
3.	Introduce deep learning models and their relevance to genomic data.
4.	Learn deep learning algorithms for classification, prediction, and disease association.
5.	Integrate real-world datasets and evaluate deep learning performance for genomic analysis.

List of Experiments:	
1	Read and display DNA sequence from FASTA format using Bioinformatics Toolbox and convert DNA sequence to numerical format using Voss representation.
2	Apply Discrete Fourier Transform (DFT) on a DNA signal and analyze frequency content.
3	Use Wavelet Transform to localize motifs in DNA sequences.
4	EIIP representation for a gene and extract energy signatures
5	Implement PCA to reduce dimensionality of genomic features.
6	Build a simple feedforward neural network for classifying DNA sequences.
7	Train a Convolutional Neural Network (CNN) to detect promoter regions.
8	Develop an LSTM network for sequence classification (e.g., exon-intron).
9	Compare training performance of CNN and RNN on the same genomic dataset
10	Apply Auto encoder for feature learning from gene expression data.
11	Classify cancer gene expression data using a deep neural network.
12	Evaluate performance metrics (accuracy, precision, recall, ROC) for your model.
13	Apply t-SNE for visualizing high-dimensional genomic features.
14	Perform model explainability analysis using SHAP values for genomic data.

TEXT BOOKS		
1	Devisetty, Upendra Kumar	Deep Learning for Genomics: Data-driven approaches for genomics applications in life sciences and biotechnology. Packt Publishing Ltd, 2022.

REFERENCE BOOKS		
1	Khaliz Raja	Deep Learning in Genetics and Genomics, Volume-I, Academic Press 2024,

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Apply the core concepts of genomics and digital signal processing techniques to digitally represent DNA/RNA sequences in the field of Biomedical Engineering.
CO2	Apply appropriate numerical representations and extract meaningful features from genomic sequences.
CO3	Design and implement deep learning models tailored for genomic sequence analysis.
CO4	Demonstrate the ability to solve real-world genomic problems using deep learning approaches.
CO5	Analyze, evaluate, and interpret results from genomic DL models on real datasets.

Course Articulation Matrix

		POs											PSOs		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
COs	**CO1**	3	1			1			1	2		1		3	
	CO2	2	2			1			1	2		1		3	
	CO3	2	2	1		1			1	2		1		3	
	CO4	2	2	1		1			1	2		1		3	
	CO5	2	2	1		1			1	2		1		3	

MANAGEMENT AND ENTREPRENEURSHIP

Contact Hours/ Week:	L:T:P:: 3:0:0	**Credits:**	3
Total Lecture Hours:	42	**CIE Marks:**	50
Course Code:	SHS08	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Understand the principles and functions of management through planning
2.	Analyze the importance of organizing and staffing in an organization
3.	Analyze the importance of leading and controlling in an organization
4.	Inculcate entrepreneurial qualities and understand the need of rural entrepreneurship
5.	Acquire knowledge about funding agencies, understand procedure in applying for funds and analyze the cases of successful entrepreneurs

UNIT I
Introduction to Management: Definition of management, management skills, productivity and effectiveness, efficiency, functions and principles of management. Planning: Nature of planning, types of plans- purpose of vision, mission, goals, objectives strategies, policies; steps in planning, MBO, Strategic planning.
7 Hours

UNIT II
Organizing: Formal and informal organization, span of management, the structure and Process of organizing, Organizational structure: line and staff organization, Functional organization, matrix organization. Staffing: Definition, systems approach to HRM, factors affecting staffing, recruitment and selection, job design, skill and characteristics of a manager, selection process and techniques
8 Hours

UNIT III
Leading: Human factors in managing, motivation, Theory X and Y, the hierarchy of needs theory, leadership behavior and styles. Controlling: Basic control process, critical control points and standards, Benchmarking requirements for effective control.
8 Hours

UNIT IV
Entrepreneur & Entrepreneurship: Introduction, concept of Entrepreneur, characteristics of an entrepreneur, and qualities of an entrepreneur, functions of an entrepreneur, characteristics of entrepreneurship, factors affecting entrepreneurial growth. Entrepreneurship and economic development-rural, woman and social entrepreneurship Financing and Institutional Support for Entrepreneurship: Startups, business plans, venture capitalists, angel investors, funding agencies -commercial banks, development banks, NBFCS and incubation centres. Innovations and project trends.
12 Hours

UNIT V
Taxation benefits: Depreciation allowances, rehabilitation allowance, investment allowance and other tax concession benefits to an entrepreneur. Case studies 1. Happily Bootstrapping: Zoho CEO Sridhar Vembu (2007) 2. Thought Leaders in Cloud Computing: Sridhar Vembu, CEO of Zoho (2016) 3. Building India's Amazon: Flipkart CEO Sachin Bansal 4. Rohith Bhat's Exhilarating Journey with Robosoft from Udupi, Karnataka
7 Hours

TEXT BOOKS		
1	Harold Koontz, Heinz Weihric	Harold Koontz, Heinz Weihric Essentials of Management, McGraw Hill Education, 10th Edition, 2015
2	Lucy C. Morse	Managing Engineering and Technology, Pearson Education, 6th Edition, 2015.
3	S.S. Khanka	Entrepreneurial Development, S. Chand Publishing, 4th Edition, Reprint, 2020, ISBN 978-81-219-1801-5

REFERENCE BOOKS		
1	James A.F. Stoner, R. Edward Freeman, Daniel R. Gilbert	Gilbert Management, Pearson Education, 6 th Edition, 2018

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Explain various functions of management.
CO2	Apply the knowledge of management principles and strategies in various functional areas such as organizing and staffing.
CO3	Apply the knowledge of management principles and strategies in various functional areas such as Leading and Controlling.
CO4	Describe entrepreneurship, its characteristics, and benefits and identify various funding sources for starting a business venture
CO5	Explain various taxation benefits enjoyed by an entrepreneur and analyze the characteristics and strategies adopted3 by successful entrepreneurs.

Course Articulation Matrix

		POs											**PSOs**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
COs	**CO1**	3					1						3	3	
	CO2	3										3	3	3	
	CO3	3										3	3	3	
	CO4	3					2				2	3	3	3	
	CO5	3	3									3	3	3	3

BIOPHARMACEUTICALS AND REGULATORY AFFAIRS

Contact Hours/ Week:	L:T:P::3:0:0	**Credits:**	3
Total Lecture Hours:	42	**CIE Marks:**	50
Course Code:	S7BTPE11	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Study the basic concepts of biopharmaceuticals and understand the different types of expression system
2.	Understand the necessities of the drug manufacturing process.
3.	Learn the concepts of vaccines production and antisense technology.
4.	Study the concepts of clean room and its importance in manufacturing pharma products.
5.	Understand the importance of regulatory affairs in pharma industry

UNIT I

Biopharmaceuticals: Introduction to Biopharmaceuticals and pharmaceutical biotechnology, History of the pharmaceutical industry, the age of biopharmaceuticals, Biopharmaceuticals: Status and future prospects, Traditional pharmaceuticals of biological origin. Sources of biopharmaceuticals: *E.coli* as a source of recombinant, therapeutic proteins, Expression of recombinant proteins in animal cell culture system. Host-Vector Interactions in *E.coli*, parameters influencing the productivity of Recombinant *E.coli* Cultivations. Additional production systems: yeasts, fungal production systems, transgenic animals, transgenic plants, Insect cell-based systems. Production of final product, cell banking systems, upstream processing, microbial cell fermentation. Mammalian cell culture systems.

9 Hours

UNIT II

The drug manufacturing process: The manufacturing facility: Clean rooms, cleaning, decontamination and sanitation (CDS), CDS of the general manufacturing area, water for biopharmaceutical processing, generation of purified water and water for injections (WFI), distribution system for WFI.

The drug development process: Drug discovery: The impact of genomics and related technologies upon drug discovery, Gene chips, Proteomics, Structural genomics Pharmacogenetics. Plants as a source of drugs: Microbial drugs, Rational drug design, Combinatorial approaches to drug discovery, Initial product characterization. Delivery of biopharmaceuticals: Oral delivery systems, Pulmonary delivery, Nasal, transmucosal and transdermal delivery systems.

9 Hours

UNIT III

Vaccines: Vaccine technology–Traditional vaccine preparations (attenuated, dead or inactive bacteria; attenuated and inactivated viral vaccines); Toxoids, antigen-based and other vaccine preparations; The impact of genetic engineering on vaccine technology – peptide vaccines and Vaccine vectors; Development of an AIDS vaccine and difficulties associated with vaccine development; Cancer vaccines. Nucleic acid and therapeutics: Gene therapy-basic approach, vectors used in gene therapy (Retroviral vectors, manufacture of viral vectors), Gene therapy and genetic disease. Anti-sense technology – antisense oligonucleotides, uses, advantages and disadvantages of 'Oligos', delivery and cellular uptake of oligonucleotides.

	8 Hours

UNIT IV
Cleanroom: What is a Cleanroom? The Need for Clean rooms, Types of Cleanrooms, What is Cleanroom Technology? Basis of Clean room Standards, Federal Standard 209. Airborne Particle Counters, Measurement of Particle Concentrations (IS0 14644- 1) - Sample locations and number, Airborne sampling volume, Acceptance criteria, Microbial Counts - Microbial Sampling of the Air - Impaction onto agar, Microbial Deposition onto Surfaces, Microbial Surface Sampling – Contact surface sampling, Swabbing, Personnel sampling Operating a Clean room: Contamination Control - Identification of Sources and Routes of Contamination - Sources of contamination. Clean room Disciplines, Clean room Clothing, Routes and Sources of Microbial Dispersion, Types of Clean room clothing.
8 Hours

UNIT V
Quality life cycle: Introduction; Good laboratory practice (GLP) -GLP in Europe, GLP in the UK, GLP in the USA; Good clinical practice (GCP) - GCP in the USA, GCP in Europe, ICH guidelines on GCP, Good manufacturing practice (GMP); Good distribution practice (GDP). Quality assurance and control - Introduction; Relationship between quality management, QA, GMP and QC; Definition of quality management; Definition of quality assurance; Definition of quality control; Responsibilities of QA –QA requirements in EU, PIC/S, WHO and FDA; Responsibilities of QC. Quality systems: ISO 9000 series; ISO 14000 series. Good manufacturing practice - Definition of GMP; Different versions of GMP (UK,European Union, USA, Australia, WHO, Arab World); Responsibilities under GMP; Rules versus guidelines. Good distribution practice - Principles of GDP; Quality system.
8 Hours

TEXT BOOKS		
1.	Gary walsh	Biopharmaceuticals- Biochemistry and Biotechnology, Wiley-Blackwell, 2nd Edition, 2003, 978-0470843277.

REFERENCE BOOKS		
1	W Whyte	Clean Room Technology – Fundamentals of Design, Testing and Operation, John Wiley and Sons, 1st Edition, 2010, 978-0470858387.
2	G. Walsh, B. Murphy	Biopharmaceuticals, an Industrial Perspective, Springer Netherlands, 1st Edition, 2010, 978-9048152377.

Course Outcomes:
Upon completion of this course the student will be able to:

CO1	Classify different types of expression system and outline the production of biopharmaceutical products
CO2	Explain the various requirements of drug manufacturing process and highlight the importance of drug development process
CO3	Discuss various methods of vaccine production and interpret the concepts of gene therapy and antisense technology in treating human diseases
CO4	O Outline the requirement of cleanroom facilities, implementation of ISO standards in pharmaceutical industry
CO5	Summarize various regulatory bodies, quality control and quality assurance in biopharmaceutical industry

Course Articulation Matrix

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	1												3
	CO2	2	1												3
	CO3	2	2												3
	CO4	2	2												3
	CO5	2	2												3

NANOBIOTECHNOLOGY

Contact Hours/ Week:	L:T:P::3:0:0	**Credits:**	3
Total Lecture Hours:	42	**CIE Marks:**	50
Course Code:	S7BTPE12	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	To understand the principles and applications of nanobiotechnology.
2.	To learn the synthesis and characterization techniques in nanobiotechnology.
3.	To comprehend the current applications of nanobiotechnology in diagnostics
4.	To learn the applications of nanobiotechnology in Biomedical Sciences
5.	To comprehend safety issues related to nanobiotechnology

UNIT I
INTRODUCTION: A Brief History, Definition of nanotechnology, Nanobiotechnology v/s Bionanotechnology, Bottom-Up versus Top-Down approaches; Methods of synthesis of nanoparticles – Physical (bead mill, laser ablation) chemical (sol-gel, precipitation, chemical reduction) and biological (use of microbes, enzymes, plant materials), parameters affecting nanoparticle growth, shape, size and structure. Structure-property relationships in materials, Nanolithography-UV and electron beam. Fabrication in Soft Materials: Hydrogels/PDMS/other polymers for biological applications
9 Hours

UNIT II
NANOMATERIALS AND THEIR CHARACTERIZATION : Fullerenes - Buckyballs, carbon nanotubes, Carriers, Dendrimers, Nanoparticles, Nanocomposites, Nanoshells, Quantum Dot, Principle, Instrumentation and applications of UV, FTIR, Raman shift, Surface Plasmon resonance (SPR), SEM, TEM, Atomic force microscopy Dynamic light scattering (DLS), XRD.
8 Hours

UNIT III
NANOMOLECULAR DIAGNOSTICS: Rationale of Nanotechnology for molecular diagnostics, Bio-functionalization methods, Nanoparticles like Gold, Quantum Dots, and Magnetic Nanoparticles in diagnostics, Bio-nanohybrids-with relevant applications. Nanopore technology, Nano arrays. Nanobiosensors: cantilever, carbon nanotube, nanowires. Pathogen detection by magnetic nanoparticle-based techniques. Miniaturized devices in nanobiotechnology - types and applications, lab on a chip concept.
8 Hours

UNIT IV
BIOMEDICAL AND LIFE SCIENCES APPLICATIONS: Introduction to nanomedicine, nanocapsules, nanorobots, nanopharmacology. Use of micro needles and nanoparticles for local highly controlled drug delivery. Nanotechnology products and applications in ocular, oncology, neurology and cardiology. Functions and applications of DNA based nanostructures, Biomimetic fabrication of DNA based metallic nanowires and networks, Biomolecular nanomotors (ATP synthase complex and flagella).
8 Hours

UNIT V
ETHICS, SAFETY AND REGULATORY ASPECTS : Introduction, ethical, legal and social implications of Nano medicine, and nano-bio-products, Safety concerns- Health Risks, and Challenges. Assessment of the toxic effects of nanoparticles based on in-vitro & In-Vivo experiments. Case studies. Environmental effects, public perceptions, Guidelines and regulatory aspects and evaluation of Nanopharmaceuticals in India, Europe and USA, challenges and risks associated with Markets for Nano medicine. Trends in Research and education.
9 Hours

TEXT BOOKS		
1	Pradeep T.,	A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd., 2012.
2	Hari Singh Nalwa	Nanostructured Materials and Nanotechnology", Academic Press, 2002.
3	Stephen Lee and Lynn M Savage	Biological molecules in Nanotechnology, International Business Communications, Inc

REFERENCE BOOKS		
1	Nabok A	"Organic and Inorganic Nanostructures", Artech House, 2005.
2	Dupas C., Houdy P., Lahmani M.,	"Nanoscience: Nanotechnologies and Nanophysics", Springer-Verlag Berlin Heidelberg, 2007.

Course Outcomes:
Upon completion of this course the student will be able to:

CO1	Eloborate the principles of nanobiotechnology
CO2	Apply the synthesis and characterization techniques in nano-biotechnology

CO3	Demonstrate the current applications of nanobiotechnology in diagnostics
CO4	Analyse the utilization of nanobiotechnology in Biomedical and Life sciences
CO5	Apply the ethical principles in understanding nanobiotechnology

Course Articulation Matrix

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	3
COs	CO1	2	1									3			3
	CO2	2	1			3									3
	CO3	2	2			2									3
	CO4	2	2			2									3
	CO5	2	2												3

FORENSIC SCIENCE TECHNOLOGY

Contact Hours/ Week:	L:T:P::3:0:0	**Credits:**	3
Total Lecture Hours:	42	**CIE Marks:**	50
Course Code:	S7BTPE13	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Learn the history & development , different areas of forensic science
2.	Understand the documentation, collection of physical evidence & classification of forensic laboratories
3.	Study the types of courts & understand the scope of anthropology
4.	Know about forensic toxicology & pathology
5.	Learn about genetics & ethics of forensic science

UNIT I
Introduction to forensic science: Definition and Scope, special areas of Forensic science-pathology, toxicology, anthropology, odontology, engineering, biology, geology, psychiatry, questioned documents, criminalistics, jurisprudence etc. History and Development of Forensic science. Examination of dead & living cases. Crime scene investigation, Medico legal investigation, Colonial Period, The Republic, The Twentieth Century, New York System, California, European Developments in Criminalistics, American Developments in Criminalistics structure of evidence.
9 Hours
UNIT II

Crime lab: Introduction to documentation & collection of physical evidence, Types of physical evidence-Body fluids, Body tissues, Drugs and controlled substances, Fibers, Finger, palm, and foot prints, Fire and explosive materials, Firearms and projectile stools, Glass, Hair, Oils and grease or cosmetic products, Paint and paint products-separating complete mixtures, light microscopy. Classification of Laboratories, Typical Sections of the Forensic or Crime Laboratory, Toxicology and Drug Identification, Arson Analysis-Steam distillation, Solvent extraction, Cold head space, Heated head space, Vapor concentration on charcoal. Typical selections of forensic or crime lab- Toxicology & drug identification, firearms & tool marks, trace evidence, finger print identification, forensic photography submitting evidence.

8 Hours

UNIT III

Scientific evidence in court: Types of courts- **:** Equitable, Admiralty, Law, Coroner, Grand Jury, State and Federal. Types of courts of law-civil &criminal. Evidence Testamentary and Demonstrative or Physical, Types of Testamentary Witnesses, Fact Witnesses, Expert Witnesses, Hypothetical Questions, Role of the Judge Legal medicine &jurisprudence: investigating systems, medicolegal issues, forensic expert, education & employment. Scope of anthropology: Introduction, identification of Forensic taphonomy, demographic characteristics of skeleton. Personal identification, facial imaging, facial reconstruction, photographic comparison.

8 Hours

UNIT IV

Forensic pathology: Rigor mortis, Algor mortis. Forensic Anthropology, Forensic Entomology, Forensic Psychiatry, Forensic Odontology, Forensic Engineering, DNA Analysis, Dactyloscopy, Finger prints : Classification and patterns. Forensic toxicology: History of Forensic Toxicology Deaths investigated by toxicologists, Accidental Poisoning, Deaths from Drug Abuse, Suicidal Poisoning, Homicidal Poisoning, Toxicological Investigation of a Poison Death, toxicological analysis, types of poisons -Gases, Steam Volatile Poisons, Metallic Poisons, Nonvolatile Organic Poisons, Miscellaneous Poisons & types of tests.-Color Test, Micro diffusion Test, Chromatography Thin-Layer Chromatography, Gas Liquid Chromatography, Spectroscopy.

8 Hours

UNIT V

Forensic Genetics: DNA typing, serology-Physical Properties of Blood, blood stain pattern interpretation, Angle of Impact, Points of Convergence, Point of Origin, Low-Velocity Bloodstain Patterns, Medium-Velocity Bloodstain Patterns, High-Velocity Bloodstain Patterns biological analysis of body fluids, genetic markers, DNA finger print profile, autoradiogram, PCR technology, RFLPs, VNTRs, biological material collection, characterization & storage. Ethics in Forensics: The importance of professional ethics to science practitioners, Development of code of conduct and code of ethics for forensic science.

9 Hours

TEXT BOOKS

1	Introduction to Forensic science, 2nd edition	Williams G.Eckert, CRC PRESS, Elsevier 1992
2	An introduction to Forensic genetics	William Goodwin, Adrian Linacre, SIbte. 1807Wiley 2007 John Wiley & sons ltd. (ISBN)

REFERENCE BOOKS

1	Hand book of Forensic services	Kim Waggoner, An FBI laboratory publication.

Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Describe the examination of dead & living cases
CO2	Classify the laboratories, typical sections of forensic or crime laboratory
CO3	Describe the types of courts of law: civil & criminal
CO4	Explain the finger print classification & patterns, rigor mortis & algor mortis
CO5	Explain the importance of professional ethics

Course Articulation Matrix

	POs												**PSOs**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
COs	**CO1**	**3**	**1**												**3**
	CO2	**3**	**1**			**1**									**3**
	CO3	**3**	**2**												**3**
	CO4	**3**	**2**			**2**									**3**
	CO5	3	**2**					3				2			**3**

1: Low, 2: Medium, 3: High

COMPUTER AIDED DRUG DESIGN

Contact Hours/ Week:	L:T:P::3:0:0	**Credits:**	3
Total Lecture Hours:	42	**CIE Marks:**	50
Course Code:	S7BTPE14	**SEE Marks:**	50

Course objectives: This course will enable students to:	
1.	Study the basics of silico drug design and computer assisted lead molecule design
2.	Understand the role of molecular recognition in drug discovery process
3.	Study the molecular simulation and dynamics of biomolecules
4.	Learn how to identify potential lead compounds.
5.	Understand different approaches in *silico* drug design.

UNIT I
Insilico Drug Design and Computer Assisted New Lead Design: Drug design and discovery: an overview. Introduction, historical perspective, drug compounds, reparation and organization for drug seeking, common stages in the drug seeking campaign, sources of hits, leads and candidate drugs, Natural products: higher plant and animal products, combinatorial libraries, Lead optimization. Introduction, Basic Concepts, Molecular Recognition by Receptor and Ligand Design, Active Conformation, Approaches to Discover New Functions, Approaches to the Cases with known and unknown receptor structure. Introduction to drug metabolism, toxicity and pharmacokinetics, toxicology considerations, problems and drawbacks on drug discovery and development.
8 Hours

UNIT II
Role of molecular recognition in drug design: Introduction, thermodynamic considerations of drug binding, physical basis of intermolecular interactions: enthalpic contributions, entropic contributions, total energy of intermolecular interactions, estimating individual group components in ligand-receptor interactions and co-operativity, rules of thumb.
8 Hours

UNIT III
Molecular Modeling and Simulation: Basic principles of molecular modeling, Steps in molecular modeling - Constructing an Initial Model, Refining the Model, Manipulating the Model, Visualization. Structure Generation or Retrieval, Structure Visualization, Conformation Generation, Deriving Bioactive Conformations, Molecule Superposition and Alignment, Deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Molecular Interactions: Docking, Calculation of Molecular Properties, Energy Calculations (no derivation),Examples of Small Molecular Modeling Work, Nicotinic Ligands, Sigma Ligands, Antimalarial Agents and Basic principles of molecular dynamics simulation techniques. Types of programs available for molecular modeling-scope and limitations-interpretation of results.
8 Hours

UNIT IV
Stereochemistry in drug design: Introduction, stereoisomer, origin of stereospecificity in molecular recognition, importance of stereochemistry in drug design, methods of obtaining pure stereoisomer: resolution of racemates by crystallization of diastereomers, enantioselective chromatography, analytical methods of determining purity of stereoisomer: optical rotation, NMR spectroscopy, gas chromatography, capillary electrophoresis, mass spectroscopy.
9 Hours

UNIT V
Design and applications of prodrugs: The prodrug concept: definition, barriers to drug action, prodrug design in an industrial setting. Choice and function of the pro-moiety: cleavability of the prodrug bond, modification of physicochemical properties, macromolecular transport vectors. Bioreversible derivatives for various functional groups: Esters as a prodrugs for compounds containing carboxyl or hydroxyl groups, prodrugs for amides, imides and other NH-acidic compounds, prodrugs for amines, carbonyl groups, drug activation from intermolecular cyclization reactions, cyclic prodrugs involving two functional groups of the drug, applications of prodrug.
9 Hours

TEXT BOOKS		
1	Povl Krogsgaard and Larsen	Molecular modelling, Multivista Global Ltd., 1st Edition, 2002, 978-0298789424
2	Andrew R Leach	Molecular modelling: Principles and Applications, Pearson Education ltd., 2nd Edition, 2001, 978-0198129436

REFERENCE BOOKS		
1	Ben Leimkuhler, C Matthews	Molecular Dynamics, Springer International publishing, 3rd Edition, 2015, 978-0298129456

Course Outcomes:
Upon completion of this course the student will be able to:

CO1	Describe the process of *In Silico* drug design and computer assisted lead design.
CO2	Analyze the inter-molecular interaction and role of molecular recognition in drug design
CO3	Describe the steps involved in molecular modeling and simulation
CO4	Analyze the methods of determining the stereo-chemistry in drug design.
CO5	Apply the principles of pro drug design and its application in various pharmaceutical industries.

Course Articulation Matrix

	POs												**PSOs**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
COs	**CO1**	**2**	**1**											**2**	
	CO2	**2**	**1**											**2**	
	CO3	**2**	**2**											**2**	
	CO4	**2**	**2**											**2**	
	CO5	**2**	**2**											**2**	

VIII Semester Syllabus
2025 - 2026

List of MOOCs for VIII Semester students admitted from the AY 2025-26 onwards (NEP 2022 scheme)

Department	Biotechnology

Sl. No.	**Title of Professional Elective Course**
1	Genome editing and engineering (Prof. Utpal Bora-IIT Guwahati)
2	Drug delivery : principles and engineering (Prof. Rachit Agarwal -IISc Bangalore)
3	Biomedical Instrumentation (Prof. Varadhan SKM - IIT Madras)

Sl No.	**Open Elective Courses**
1.	Psychology of Learning (Prof. Atasi Mohanty- IIT Kharagpur)
2.	Micro irrigation engineering (Prof. Kamlesh Narayan Tiwari -IIT Kharagpur)
3.	Artificial Intelligence in Drug Discovery and Development (Prof. Rajnish Kumar - IIT (BHU) Varanasi)
4.	Cyber Security and Privacy (Prof. Saji K Mathew - IIT Madras)
5.	Artificial Intelligence: Search methods for problem solving (Prof. Deepak Khemani - IIT Madras)
6.	Introduction to machine learning (Prof. Balaraman Ravindran - IIT Madras)

PROFESSIONAL ELECTIVE COURSE SYLLABUS

1. GENOME EDITING AND ENGINEERING

(Prof. Utpal Bora-IIT Guwahati)

Weblink	https://onlinecourses.nptel.ac.in/noc25_bt52/preview

Course contents		
Week 1	Introduction to genetics and genetic engineering	
Week 2	Breakage and Repair Of Genomic DNA	
Week 3	Recombination	
Week 4	Targeted genetic modification	
Week 5	Zinc Finger Nuclease (ZFN) Technology	
Week 6	Transcription activator-like effector nuclease (TALEN) Technology	
Week 7	Clustered regularly interspaced short palindromic repeats (CRISPR)/Cas9 technology	
Week 8	Applications of genome editing in treating human diseases	
Week 9	Genome engineered Disease modeling	
Week 10	Engineered immune cells for cancer therapy	
Week 11	Personalized therapy; Challenges: safety and specificity	
Textbook(s)		
1	Harber , J. E.,	Genome Stability: DNA Repair and Recombination , Garland Science, 2013

2	Yamamoto, T. ,.	Targeted Genome Editing Using Site-Specific Nucleases, Springer, 2015

Reference Book(s)		
1	Zlatanova, J. and Holde, K. van	Molecular Biology: Structure and Dynamics of Genomes and Proteomes. Garland Science, 2015
2	Yamamoto, T.(Ed.)	Targeted Genome Editing Using Site-Specific Nucleases: ZFNs, TALENs, and the CRISPR/Cas9 System , Springer 2015.
3	Barrangou , R. and Oost, J. van der	CRISPR-Cas Systems: RNA-mediated Adaptive Immunity in Bacteria and Archaea , Springer, 2013.
4	Addgene	CRISPR 101:A Desktop Resource , January 2016
5	Alberts , B. , Johnson , A., Lewis , J., Morgan, D., Raff, M., Roberts, K.and Walter, P.	Molecular Biology of the Cell, 6th Edn., Garland Science, 2014

2. DRUG DELIVERY: PRINCIPLES AND ENGINEERING

(Prof. Rachit Agarwal -IISc Bangalore)

Weblink	https://onlinecourses.nptel.ac.in/noc25_bt55/preview

Course contents	
Week 1	Pharmacokinetics: Bioavailability, Elimination, Therapeutic index
Week 2	Prodrugs, Controlled release
Week 3	Polymers: Synthesis, properties, characterization, crystallinity and amorphousness
Week 4	Biopolymers: Natural and Synthetic, biocompatibility, Biodegradation, commonly used biopolymers
Week 5	Polymer-Drug conjugates, PEGylation
Week 6	Diffusion controlled systems, Ficks laws, Reservoir systems, Non-erodible matrix systems, Bio-erodible Systems
Week 7	Hydrogels: Physical or chemical, pore-size calculation, in-situ crosslinking
Week 8	Nano and Micro-particles: Dendrimers, Liposomes, Micelles
Week 9	Metal and polymeric particles, effect of particle shape, charge and elasticity
Week 10	Protein Adsorption and tissue engineering, Drug delivery in tissue engineering
Week 11	Implant associated infections, Route specific delivery: Oral, Subcutaneous, Intramuscular, transdermal, inhalation, intravenous
Week 12	Vaccines, Cancer vaccines, Cell and gene delivery, Smart responsive drug delivery, Targeted drug delivery, Nanotoxicology and market translation

Textbook(s)		
1	W. Mark	Drug Delivery: Engineering Principles for Drug Therapy,
	Saltzman	Oxford University Press, 2001

Reference Book(s)		
1	Anya M. Hillery and Kinam Park,	Drug Delivery: Fundamentals and Applications, 2nd Edition, CRC Press, 2016

3. BIOMEDICAL INSTRUMENTATION

(By Prof. Varadhan SKM - IIT Madras)

Weblink	https://onlinecourses.nptel.ac.in/noc25_bt49/preview

Course contents		
Week 1	Module I	Introduction to Biomedical Instrumentation and Sensors
		Human Anatomy and Physiology relevant to Biomedical Instrumentation and Sensors
		Types of Biomedical Sensors (Optical, Chemical, Electrical etc)
Week 2	Module II	Sensor Characteristic (Sensitivity, Selectivity, Stability, Response Time and Accuracy)
		Use of Metamaterial in Biomedical Applications
Week 3	Module II	Bio potentials and electrodes
		Characteristic of Bio potentials and electrodes
		Electrodes and its types
Week 4	Module III	Electrocardiography (ECG)
		Electromyography (EMG),
		Electroencephalography (EEG)
Week 5	Module III	X-Ray Imaging
		Computed Tomography (CT)
		Magnetic Resonance Imaging (MRI)
		Ultrasound Imaging
Week 6	Module IV	Echocardiogram
		Amplifiers
		Filters and Signal Conditioning
		Data Acquisition and Processing Systems
		Fourier Transforms
Week 7	Module V	Time Frequency Analysis
		Monitoring and Diagnostic System
		Blood Pressure Measurement
		Cardiac Output Measurement
		Respiratory Function Measurement
Week 8	Module VI	Therapeutic Devices
		Therapeutic and Prosthetic Devices

		Implantable Sensors and Instrumentations
		Wearable Sensors and Devices
Week 9	Module VII	Internet of things (IoT) in Healthcare
		Artificial Intelligence (AI) and Machine Learning (ML) in Biomedical Instrumentation and Sensors
		Telemedicine
		Applications of Telemedicine
Week 10	Module VII	Cyber medicine
		Clinical Data Interchange/Exchange Standards
Week 11	Module VIII	Privacy and Security concerned in Medical Data
		Regulatory Requirement of Medical Devices
		Ethical Consideration in Clinical trials and research
Week 12	Module VIII	Review of the course material
		Exam preparation and practice

Textbook(s)		
1	John G. Webster,	Medical Instrumentation Application and Design, John Wiley and sons, New York, 2004
2	Khandpur R.S,	Handbook of Biomedical Instrumentation, Tata McGraw-Hill, New Delhi, 2003.

Reference Book(s)		
1	Tatsuo Togawa,	Biomedical Sensors and Instruments, CRC Press, Germany, 2011.
2	John G. Webster,	The Physiological Measurement Handbook, CRC Press – Taylor and Francis Group, Newyork, 2015

OPEN ELECTIVE COURSE

1. PSYCHOLOGY OF LEARNING

(Prof. Atasi Mohanty- IIT Kharagpur)

Weblink	https://onlinecourses.swayam2.ac.in/cec25_ed23/preview

Course contents	
Week 1: Part-I: Learning Principles **Unit - I: Introduction to Psychology of Learning**	Learning: Theories and Applications a) Behavioural Learning theories b) Cognitive-, Bruner, Gagne c) Constructivist-, Piaget, Vygotsky
Week 2	Motivation: Concept, Theories and types a) Maslow's Need Hierarchy theory(Humanistic Approach) b) Achievement Motivation & Goal Orientations c) Learners' Academic Self-regulation
Week 3	a) Sustainable Learning Habits of Mind b) Prominent Theories of Motivation c)Learners' Engagement & Self-Efficacy
Week 4: Unit-II: Memory & Cognition	Information Processing Model of Memory- a) Sensory Memory, Working Memory, Long-term Memory b) Cognitive load & Meta-cognition
Week 5	c)Critical & Reflective thinking, Problem solving and Concept- mapping
Week 6: Unit-III: Learners' Diversity & Inclusive Education	I) Learners' diversity in the classroom II) Different Learning styles & approaches III) Meeting the Learners' Diverse Needs
Week 7: Part-II: Learning in Practice **Unit-IV: Learning Sciences**	IV. Advantages of Inclusive education for individuals and society I. Transformative Learning-(TL)
Week 8	a)Transformative Learning Theory b)Facilitating TL :Engaging Emotions c)Simulated Learning d)Critical Pedagogy
Week 9: II. Experiential Learning-(EL)	a) Theoretical Foundations of EL b) Dynamic Debriefing c) EL Methodologies d) Applications of EL e) Learning Styles
Week 10: III. Multimedia Learning-(ML)	a) Theoretical Foundations of ML b) Basic Principles of ML c) Applications in E-learning Contexts d) Virtual Learning e) Online Learning f) Hybrid Learning

Week 11: IV.Social Interaction and Collaborative Learning	a) Web-based Learning (WBL) b) Integrated E-Learning (IEL) c) Blended Learning with Flipped Instruction d) Project-based Learning (PL) e) Problem-based Learning (PBL) f) Cyber-Physical-Social Learning
Week 12: V. Personalized Learning- (PL)	a) Game-based Learning (GBL) b) Self-directed Online Learning (SOL) c) Mobile Learning (ML) d) Cognitive & Affective Tutoring e) Contemplative Learning

Textbook(s)		
1	Aggarwal, J.C	Essentials of Educational Psychology. New Delhi: Vikas Publishing House. (1994).
2	Bengale, M.D.	Guidance and Counselling. Bombay: Sheth Publishers. (1984).

Reference Book(s)		
1	Chand, T	Modern Child Psychology. New Delhi: Anmol Publications (1993)
2	Chauhan, S.S	Advanced Educational Psychology New Delhi: Vikas Publishing House (2006).

2. MICRO IRRIGATION ENGINEERING

(Prof. Kamlesh Narayan Tiwari -IIT Kharagpur)

Weblink	https://onlinecourses.nptel.ac.in/noc25_ag20/preview

Course contents	
Week 1	
Lecture 1	Micro-Irrigation: Introduction and Scope
Lecture 2	Fundamentals of Fluid Mechanics and its Application in Micro Irrigation
Lecture 3	Soil Water Concept
Lecture 4	Soil Water Constants and Infiltration
Lecture 5	Tutorial 1-Numerical Examples on Fluid Mechanics and Soil Water
Week 2	
Lecture 6	Evapotranspiration
Lecture 7	Determination of Evapotranspiration
Lecture 8	Crop Coefficients and Crop Water Requirement
Lecture 9	Demonstration of Agro-Meteorological Instruments
Lecture 10	Demonstration of Lysimeter
Lecture 11	Tutorial 2 - Numerical Examples on Crop Water Requirement
Week 3	
Lecture 12	Irrigation Scheduling
Lecture 13	Soil and Plant Water Monitoring Instruments
Lecture 14	Measurement of Irrigation Water
Lecture 15	Irrigation Efficiency
Lecture 16	Tutorial 3 - Numerical Examples on Irrigation Water Management

Week 4	
Lecture 17	Introduction of Water Lifts and Pumps
Lecture 18	Variable Displacement Pumps
Lecture 19	Irrigation Water Quality
Lecture 20	Tutorial 4 - Numerical Examples on Water Measurements and Pumps
Lecture 21	Irrigation Methods
Week 5	
Lecture 22	Micro Irrigation System: Concept and Types
Lecture 23	Drip Irrigation: Introduction and Types
Lecture 24	Drip Irrigation: Design Considerations & System Layout
Lecture 25	Types and Selection of Emission Devices
Lecture 26	Hydraulics of Drip Irrigation System Pipe Network
Week 6	
Lecture 27	Tutorial 5 - Numerical Example on Design of Drip Irrigation System
Lecture 28	Fertigation
Lecture 29	Fertigation Application Methods
Lecture 30	Drip Irrigation: Filtration System
Lecture 31	Tutorial 6 - Numerical Examples on Emission Devices and Fertigation
Week 7	
Lecture 32	Installation and Operation of Drip Irrigation System
Lecture 33	Maintenance of Drip Irrigation System
Lecture 34	Demonstration of Drip Irrigation Components and Evaluation of Drip Emitters
Lecture 35	Soil Water Movement under a Drip Emitter
Lecture 36	Design and Development of Drip Emitters
Week 8	
Lecture 37	Tutorial 7- Numerical Examples on Drip Irrigation System
Lecture 38	Micro Sprinkler Irrigation System
Lecture 39	Bubbler Irrigation System
Lecture 40	Sprinkler Irrigation System
Lecture 41	Sprinkler Irrigation System Design
Week 9	
Lecture 42	Performance Evaluation of Sprinkler Irrigation System
Lecture 43	Tutorial 8 - Numerical Examples on Sprinkler Irrigation System
Lecture 44	Tutorial 9 - Numerical Examples on Design of Sprinkler Irrigation System
Lecture 45	Sprinkler Irrigation System: Layout, Installation, Operation and Maintenance
Week 10	
Lecture 46	Standards and Quality Assurance of Drip Irrigation System Components
Lecture 47	Standards and Quality Assurance of Sprinkler Irrigation System Components
Lecture 48	Solar PV System for Irrigation (Part 1)
Lecture 49	Solar PV System for Irrigation (Part 2)
Lecture 50	Tutorial 10 - Numerical Examples on Solar PV Irrigation System

Week 11	
Lecture 51	Automation of Micro Irrigation System (Part 1)
Lecture 52	Automation of Micro Irrigation System (Part 2)
Lecture 53	Automation of Micro Irrigation System (Part 3)
Lecture 54	Automation of Micro Irrigation System (Part 4)`
Lecture 55	Economic Analysis of MIS (Part 1)
Week 12:	
Lecture 56	Economic Analysis of MIS (Part 2)
Lecture 57	Economic Analysis of MIS (Part 3)
Lecture 58	Tutorial 11- Numerical Examples on Economics of MIS
Lecture 59	Precision Agriculture
Lecture 60	Micro Irrigation Engineering: Epilogue

Textbook(s)		
1	Ćulibrk, D., Vukobratovic, D., Minic, V.,	Sensing technologies for precision irrigation. Springer New York, 2014.
	Fernandez, M. A., Osuna, J. A., & Crno-jevic, V.	
2	Goyal, M. R.	Management of drip/trickle or micro-irrigation. CRC Press, 2012

Reference Book(s)		
1	Holler, J., Tsiatsis, V., Mulligan, C., Karnouskos, S., Avesand, S., & Boyle, D.	Internet of Things. Academic Press,2014
2	James, Larry G.	Principle of Farm Irrigation System Design, John Wiley and Sons, New York. 1988

3. ARTIFICIAL INTELLIGENCE IN DRUG DISCOVERY AND DEVELOPMENT

(Prof. Rajnish Kumar - IIT (BHU) Varanasi)

Weblink	https://onlinecourses.nptel.ac.in/noc25_ch96/preview

Course contents	
Week 1: Basics of drug discovery pipeline	1. Drug discovery and development 2. Overview of drug discovery workflows 3. Drug design strategies 4. Conventional methods for drug discovery 5. Riddles in drug discovery
Week 2: Introduction to AI in drug discovery and development	1. History and evolution of AI in drug discovery 2. Overview of AI technologies 3. Key applications of AI across the pipeline 4. Available AI tools and platforms 5. Advantages of AI integration in drug discovery

Week 3: Fundamentals of AI and ML techniques	1. Introduction to machine learning concepts 2. Overview of neural networks 3. Feature engineering and data preprocessing 4. Evaluation metrics for AI models 5. Introduction to Python libraries for AI in drug discovery
Week 4: AI in target identification, prediction and validation	1. Introduction to biological targets 2. Basics of target identification and validation 3. Omics data integration for target discovery 4. Binding site and protein structure prediction with AI 5. Hands-on tutorial: Protein structure prediction
Week 5: AI in high throughput virtual screening and lead identification	1. Introduction and approaches to virtual screening 2. AI tools for virtual screening 3. AI assisted molecular docking 4. Workflow of high-throughput virtual screening 5. Hands-on tutorial: AI-assisted molecular docking
Week 6: AI in lead optimization and drug-target interaction	1. Basics of lead optimization 2. AI for drug-target interaction studies 3. QSAR modelling 4. Molecular dynamics simulations 5. Hands-on tutorial: Molecular dynamics trajectory analysis
Week 7: ADMET predictive modelling in drug discovery	1. Introduction to ADMET Properties 2. Importance in lead optimization 3. Conventional methods for ADMET prediction 4. Open available resources for ADMET prediction 5. Hands-on tutorial: AI-enabled ADMET prediction
Week 8: AI in clinical phase	1. Overview of clinical trials 2. Patient recruitment, stratification, and retention 3. Clinical trial protocol design and optimization 4. Predicting outcomes of clinical trials with AI 5. Data collection and monitoring for regulatory submissions
Week 9: De Novo Drug Design using Generative AI	1. Introduction to Generative AI in drug design 2. Deep Generative Models for drug design (GAN, GNN, RNN, VAE etc.) 3. Benchmarking Generative Models for drug design 4. Molecule optimization with Generative AI 5. Hands-on tutorial: AI-powered de novo drug design
Week 10: Advanced concepts: Precision medicine, Network pharmacology and Drug repurposing	1. AI in genomics for personalized treatments 2. AI in real-time monitoring and feedback 3. Overview and data sources for AI in drug repurposing 4. Integrating multi-target drug discovery 5. Network pharmacology with AI
Week 11: Case studies, challenges, future directions, and resources	1. Public AI resources for drug discovery 2. Examples of notable successful case studies 3. Challenges in modern drug discovery realm 4. Regulatory considerations for AI implementation in drug development 5. Future outlook: Explainable artificial intelligence, (XAI) and other emerging technologies in drug discovery

Week 12: Hands-on sessions (Implementing an advanced workflow for molecular structure representation, property prediction, and ultra-large virtual screening)	1. Molecular structure representation 2. ML-assisted solubility prediction 3. AI-assisted bioactivity prediction 4. Pharmacophore- based ultra-large virtual screening 5. Similarity based virtual screening

Textbook(s)		
1	Ramsundar, B., Eastman, P., Walters, P., & Pande, V.	(2019). Deep learning for the life sciences: applying deep learning to genomics, microscopy, drug discovery, and more. O'Reilly Media, Inc.,2019

Reference Book(s)		
1	Brown, N.	Artificial intelligence in drug discovery. Royal Society of Chemistry. 2020

3. CYBER SECURITY AND DATA PRIVACY

(Prof. Saji K.Mathew - IIT Madras)

Weblink	https://onlinecourses.nptel.ac.in/noc25_cs116/preview

Course contents	
Week 1	Introduction - Introduction to cyber security, Confidentiality, integrity, and availability. R1. From information security to cyber security. Computers and Security, 2013, accessible at: https://www.sciencedirect.com/science/article/pii/S0167404813000801
Week 2	Foundations - Fundamental concepts, CIA, CIA triangle, data breach at target. R2. Chapter 1- Text R3. Why you should care about the Target data breach? Business Horizons, 2016, accessible at:https://www.sciencedirect.com/science/article/abs/pii/S0007681316000033
Week 3	Security management, Governance, risk, and compliance (GRC)- GRC framework, security standards. R4. Text-Chapter 4 - Planning for security, pp. 171- 176
Week 4	Contingency planning - Incidence response, Disaster Recovery, BCP. R5. Text-Chapter 4 - Planning for security, pp. 214-251
Week 5	Cyber security policy - ESSP, ISSP, SYSSP.R6. Text-Chapter 4- Infor- mation security policy, pp. 177-213. R7. Internet insecurity: The end of cyber security. HBR, 2018, accessible at: https://hbr.org/2018/05/internet-insecurity
Week 6	Risk Management - Cyber Risk Identification, Assessment, and Control.R8. Text-Chapter 5- Risk management: Identifying and assessing risk. R9. Case Study- Protecting the Cheddar: The end of cyber security. HBR, 2018, accessible at: https://hbr.org/2018/05/case-study-protecting-the-cheddar

Week 7	Cyber security: Industry perspective - Defense Technologies, Attack, Exploits R10. Text-Chapter 6-7- Security technology
Week 8	Cyber security technologies - Access control, Encryption, Standards. R11. Text-Chapter 8- Cryptography R12. Active defense and hacking back: A primer- The end of cyber security. HBR, 2018, accessible at: https://hbr.org/2018/05/active-defense-and-hacking-back-a-primer?ab=seriesnav-bigidea
Week 9	Foundations of privacy - Information privacy, Measurement, Theories. R13. Privacy, Stanford Encyclopedia of Philosophy, 2013, accessible at: https://plato.stanford.edu/entries/privacy/ R14. We Googled you. HBR Online, 2007, accessible at: https://hbr.org/2007/06/we-googled-you-2
Week 10	Privacy regulation - Privacy, Anonymity, Regulation, Data Breach.R15. Text-Chapter 3- Law and ethicsR16. UNCTAD. Data Protection and Priva- cy Legislation Worldwide, accessible at: https://unctad.org/page/data-protection-and-privacy-legislation-worldwide
Week 11	Privacy regulation in Europe, Privacy: The Indian Way - Data Protection, GDPR, DPDP, Aadhar.R17. GDPR: General Data Protection Directive (https://gdpr-info.eu) R18. Privacy and security of Aadhaar: A Computer Science perspective, IIT Delhi, accessible at: https://www.jstor.org/stable/pdf/26697657.pdfR19. The digital personal data protection bill, 2023 https://www.meity.gov.in/writereaddata/files/Digital%20Personal%20Data%20Protection%20Protection%202023.pdf
Week 12	Information privacy: Economics and strategy, Economic value of privacy, privacy valuation, WTA and WTC, Business strategy and privacy, espio- nage, Privacy vs safety. R20. The dark side of customer analytics. HBR Case, 2007, accessible at: https://www.pomsmeetings.org/ConfPapers/052/052-0002.pdf R21. Apple privacy vs safety issues: https://hbswk.hbs.edu/item/cold-call-apples-dilemma-balancing-privacy-and-safety-responsibilities

Textbook(s)		
1	Michael E. Whitman, Herbert J. Mattord	Principles of Information Security, 6th edition, Cenage Learning, N. Delhi., 2018

Reference Book(s)		
1	Van Kessel, P.	Is cyber security about more than protection? EY Global Information Security Survey 2018-2019.
2.	Arce I. et al.	Avoiding the top 10 software security design flaws. IEEE Computer Society Center for Secure Design (CSD), 2014.

5. ARTIFICIAL INTELLIGENCE: SEARCH METHODS FOR PROBLEM SOLV- ING

(Prof. Deepak Khemani - IIT Madras)

Weblink	https://onlinecourses.nptel.ac.in/noc25_cs88/preview

Course contents	
Week 0	Introduction: History, Can Machines think?, Turing Test, Winograd Schema Challenge, Language and Thought, Wheels & Gears
Week 1	Introduction: Philosophy, Mind, Reasoning, Computation, Dartmouth Conference, The Chess Saga, Epiphenomena
Week 2	State Space Search: Depth First Search, Breadth First Search, Depth First Iterative Deepening
Week 3	Heuristic Search: Best First Search, Hill Climbing, Solution Space, TSP, Escaping Local Optima, Stochastic Local Search
Week 4	Population Based Methods: Genetic Algorithms, SAT, TSP, emergent Systems, Ant Colony Optimization
Week 5	Finding Optimal Paths: Branch & Bound, A*, Admissibility of A*, In- formed Heuristic Functions
Week 6	Space Saving Versions of A*: Weighted A*, IDA*, RBFS, Monotone Condition, Sequence Alignment, DCFS, SMGS, Beam Stack Search
Week 7	Game Playing: Game Theory, Board Games and Game Trees, Algorithm Minimax, AlphaBeta and SSS*
Week 8	Automated Planning: Domain Independent Planning, Blocks World, For- ward &Backward Search, Goal Stack Planning, Plan Space Planning
Week 9	Problem Decomposition: Means Ends Analysis, Algorithm Graphplan, Algorithm AO*
Week 10	Rule Based Expert Systems: Production Systems, Inference Engine, Match-Resolve-Execute, Rete Net
Week 11	Deduction as Search: Logic, Soundness, Completeness, First Order Logic, Forward Chaining, Backward Chaining
Week 12	Constraint Processing: CSPs, Consistency Based Diagnosis, Algorithm Backtracking, Arc Consistency, Algorithm Forward Checking

Textbook(s)		
1	Stefan Edel- kamp and Stefan Schroedl.	Heuristic Search: Theory and Applications, Morgan Kauf- mann, 2011.
2	John Hauge- land,	Artificial Intelligence: The Very Idea, A Bradford Book, The MIT Press, 1985.

Reference Book(s)		
1	Pamela Mc Corduck,	Machines Who Think: A Personal Inquiry into the History and Prospects of Artificial Intelligence, A K Peters/CRC Press; 2 edition, 2004.
2	Zbigniew Michalewicz and David B. Fogel.	How to Solve It: Modern Heuristics. Springer; 2nd edition, 2004.

6. INTRODUCTION TO MACHINE LEARNING

(Prof. Balaraman Ravindran- IIT Madras)

Weblink	https://onlinecourses.nptel.ac.in/noc25_cs91/preview

Course contents	
Week 1	Basics of Linear Algebra, Probability, Optimization
Week 2	Introduction to Supervised Learning - Regression; Topics - Linear Regression; Ridge Regression; LASSO
Week 3	Supervised Learning - Classification; Topics: K-NN, Decision Tree.
Week 4	Supervised Learning - Classification; Topics: Naive Bayes.
Week 5	Supervised Learning - Logistic Regression ,Perceptron.
Week 6	Supervised Learning - Support Vector Machines
Week 7	Supervised Learning - Ensemble Methods
Week 8	Unsupervised Learning - K-means Clustering, PCA
Week 9	Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation
Week 10	Partitional Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density-based Clustering
Week 11	Gaussian Mixture Models, Expectation Maximization
Week 12	Learning Theory, Introduction to Reinforcement Learning, Optional videos (RL framework, TD learning, Solution Methods, Applications)

Textbook(s)		
1	Trevor Hastie, Robert Tibshirani, Jerome H. Friedman	The Elements of Statistical Learning, (freely available online)
Reference Book(s)		
1	Christopher Bishop	Pattern Recognition and Machine Learning, .