RV College of Engineering®

Master of Technology (M. Tech)

BIOTECHNOLOGY

Scheme And Syllabus of I & IV Semester
(2024 Scheme)

B.E. Programs : AS, BT, CH, CS, CS - AI, CS - CD, CS - CY, CV, EC, EE, ET, IM, IS, ME.
M. Tech (13) MCA, M.Sc. (Engg.)
Ph.D. Programs : All Departments are recognized as Research Centres by VTU Except AI & AS

2024

Edition

99TH
NIRF RANKING IN ENGINEERING (2024)

1501+
Times Higher Education World University Rankings (2024)

601+
Asia University Ranking 2024

EduFuture Excellence Award
Best Private Engineering University (South)
by Zee Digital

1001+
Subject Ranking (Engineering)

801+
Subject Ranking (Computer Science)

IIRF 2024
Engineering Ranking India

NATIONAL RANK - 07
STATE RANK - 02
ZONE RANK - 04

AAA
Rating in NPTEL Local Chapter (Jan - Apr 2024)
State Ranking -1
National Ranking -16

CURRICULUM STRUCTURE

07 CREDITS PROFESSIONAL CORE COURSE

04 CREDITS BASIC SCIENCE

16 CREDITS INTEGRATED PROFESSIONAL CORE COURSE

24 CREDITS PROJECT WORK

04 CREDITS AEC

19 CREDITS PROFESSIONAL ELECTIVES

06 CREDITS INTERNSHIP

80 CREDITS TOTAL

*ABILITY ENHANCEMENT COURSES (AEC), UNIVERSAL HUMAN VALUES (UHV), INDIAN KNOWLEDGE SYSTEM (IKS), YOGA

17
Centers of Excellence

11
Centers of Competence

1569
Publications On SCI

440
Publications On Web Of Science

2842
Citations
Last 3 Years

70
Patents Filed

40
Patents Granted
Last 3 Years

61
Published Patents

29
Skill Based Laboratories Across Four Semesters

MOUS: 90+WITH INDUSTRIES / ACADEMIC INSTITUTIONS IN INDIA & ABROAD

₹5 crores
Sponsored Projects

₹14 crores
Consultancy Projects

RV College of Engineering®

Master of Technology (M. Tech)

BIOTECHNOLOGY

Scheme And Syllabus of I & IV Semester
(2024 Scheme)

B.E. Programs : AS, BT, CH, CS, CS - AI, CS - CD, CS - CY, CV, EC, EE, ET, IM, IS, ME.
M. Tech (13) MCA, M.Sc. (Engg.)
Ph.D. Programs : All Departments are recognized as Research Centres by VTU Except AI & AS

2024

Edition

Glossary of Abbreviations

1.	AS	Aerospace Engineering
2.	BS	Basic Sciences
3.	BT	Biotechnology
4.	CH	Chemical Engineering
5.	CHY	Chemistry
6.	CIE	Continuous Internal Evaluation
7.	CS	Computer Science & Engineering
8.	CV	Civil Engineering
9.	EC	Electronics & Communication Engineering
10.	EE	Electrical & Electronics Engineering
11.	EI	Electronics & Instrumentation Engineering
12.	ET	Electronics & Telecommunication Engineering
13.	GE	Global Elective
14.	HSS	Humanities and Social Sciences
15.	IM	Industrial Engineering & Management
16.	IS	Information Science & Engineering
17.	L	Laboratory
18.	MA	Mathematics
19.	MBT	M. Tech in Biotechnology
20.	MCE	M. Tech. in Computer Science & Engineering
21.	MCN	M. Tech. in Computer Network Engineering
22.	MCS	M. Tech. in Communication Systems
23.	MDC	M. Tech. in Digital Communication
24.	ME	Mechanical Engineering
25.	MHT	M. Tech. in Highway Technology
26.	MIT	M. Tech. in Information Technology
27.	MMD	M. Tech. in Machine Design
28.	MPD	M. Tech in Product Design & Manufacturing
29.	MPE	M. Tech. in Power Electronics
30.	MSE	M. Tech. in Software Engineering
31.	MST	M. Tech. in Structural Engineering
32.	MVE	M. Tech. in VLSI Design & Embedded Systems
33.	N	Internship
34.	P	Projects (Minor / Major)
35.	PHY	Physics
36.	SDA	Skill Development Activity
37.	SEE	Semester End Examination
38.	T	Theory
39.	TL	Theory Integrated with Laboratory
40.	VTU	Visvesvaraya Technological University

Postgraduate Programs

Sl. No	Core Department	Program	Code
1.	BT	M. Tech in Biotechnology	MBT
2.	CS	M. Tech in Computer Science & Engineering	MCE
3.	CS	M. Tech in Computer Network Engineering	MCN
4.	CV	M. Tech in Structural Engineering	MST
5.	CV	M. Tech in Highway Technology	MHT
6.	EC	M. Tech in VLSI Design & Embedded Systems	MVE
7.	EC	M. Tech in Communication Systems	MCS
8.	EE	M. Tech in Power Electronics	MPE
9.	ET	M. Tech in Digital Communication	MDC
10.	IS	M. Tech in Software Engineering	MSE
11.	IS	M. Tech in Information Technology	MIT
12.	ME	M. Tech in Product Design & Manufacturing	MPD
13.	ME	M. Tech in Machine Design	MMD
14.	MCA	Master of Computer Applications	MCA

DEPARTMENT OF BIOTECHNOLOGY

VISION

A premier department in Biotechnology Education, Research and Innovation with a focus on sustainable technologies for the benefit of society and environment.

MISSION

1. Create state-of-the-art infrastructure for research and training in Biotechnology.

2. Develop graduates who are ethical and socially concerned.

3. Promoting collaboration with academia, industries and research organizations at National and International level.

4. Contribute to socioeconomic development through sustainable and inclusive technologies

PROGRAMME OUTCOMES (PO)

M. Tech in Biotechnology graduates will be able to:

PO1: Independently carry out research/investigation and development work to solve problems related to biotechnological sector

PO2: Write and present a substantial technical report/document in the fields of health, pharma, bioprocess, food and Agriculture.

PO3: Apply advanced tools and techniques to design and formulate the solutions for various biotechnological challenges

PO4: Collaborate with the confluence of various domains of Biotech from academic, industry and research institutes of national or international repute, with the commitment to lifelong learning

PO5: Design and develop projects related to biotechnological and allied branches keeping performance and cost constraints into consideration.

PO6: Apply bioengineering solutions to societal and ethical needs with focus on sustainability

INDEX

I SEMESTER M.Tech												
Sl. No.	Course Code	Course Title	Credit Allocation				BoS	Category	CIE Duration (H)	Max Marks CIE	SEE Duration (H)	Max Marks SEE
			L	T/ SDA	P	Total						
1	MMA211TA	Applied Mathematics	3	1	0	**4**	MA	Theory	1.5	100	3	100
2	MBT312IA	Genetic Engineering	3	0	1	**4**	BT	Theory+Lab	1.5	100+50	3	100+50
3	MBT313IA	Multi-Omics Technology	3	0	1	**4**	BT	Theory+Lab	1.5	100+50	3	100+50
4	MBTX14AX	Professional Core Courses (Cluster Electives) (Group-A)	3	1	0	**4**	BT	Theory	1.5	100	3	100
5	MBT415SL	Skill Lab (Bioanalytical Laboratory)	0	0	2	**2**	BT	Lab	1.5	50	3	50
6	HSS116EL	Technical English	0	0	1	**1**	HSS	Lab (ONLINE)	1.5	50	2	50
		Total Credits				**19**						

Sl. No.	Code	Professional Core Courses (Cluster Electives) (Group-A)
1	MBT314A1	Biomaterials and Stem Cells for Tissue Engineering
2	MBT314A2	Human Diseases and Diagnostic Technology
3	MBT314A3	Advanced Drug Design and Discovery
4	MBT214A4	Food Technology

II SEMESTER M.Tech												
Sl. No.	Course Code	Course Title	Credit Allocation				BoS	Category	CIE Duration (H)	Max Marks CIE	SEE Duration (H)	Max Marks SEE
			L	T/ SDA	P	Total						
1	MBT321IA	Industrial Biotechnology	3	0	1	**4**	BT	Theory+Lab	1.5	100+50	3	100+50
2	MBT322IA	Bioprocess Engineering	3	0	1	**4**	BT	Theory+Lab	1.5	100+50	3	100+50
3	MBTX23BX	Program Specific Courses (Elective) (Group-B)	3	1	0	**4**	BT	Theory	1.5	100	3	100
4	MBTX24CX	Professional Core Courses (Cluster Electives) (Group-C)	3	1	0	**4**	BT	Theory	1.5	100	3	100
5	XXX325DX	Interdisciplinary Courses (Global Electives) (Group-D)	3	0	0	**3**	Res. BoS	Theory	1.5	100	3	100
6	MIM426RT	Research Methodology (NPTEL)	2	0	0	**2**	IM	NPTEL	--	--	2	50
7	MBT427DL	Design Thinking Lab	0	0	2	**2**	BT	Lab	1.5	50	3	50
		Total Credits				**23**						

Code	Program Specific Courses (Elective) (Group-B)	Code	Professional Core Courses (Cluster Electives) (Group-C)
MBT223B1	Fermentation & Enzyme Technology	MBT324C1	Bioprinting and Molecular Communications
MBT323B2	Agriculture Biotechnology for Enhanced Crop Yield and Sustainability	MBT324C2	Clinical Immunology
MBT323B3	Integrated Biological Systems	MBT324C3	Design of Bioreactors
MBT323B4	Forensic Science	MBT324C4	Advances in Genomic Sequencing

Elective D (Global Elective)							
SL. NO.	**BoS**	**COURSE CODE**	**COURSE TITLE**	**SL. NO.**	**BoS**	**COURSE CODE**	**COURSE TITLE**
1	**BT**	MBT325DA	Nature Impelled Engineering	8	**ET**	MET325DH	Electronic Navigation Systems
2	**BT**	MBT325DB	Clinical Data Management	9	**ET**	MET325DJ	Vehicular Communication Ecosystem
3	**CS**	MCN325DC	Cyber Forensics and Cyber Laws	10	**IM**	MIM325DK	Essentials of Project Management
4	**CV**	MCV325DD	Industrial Safety and Health	11	**IS**	MIS325DM	User Interface & User Experience
5	**CV**	MCV325DE	Advanced Technologies for Transportation Systems	12	**MA**	MMA325DN	Mathematical Methods for Data Science
6	**EC**	MEC325DF	Design & Implementation of Human-Machine Interface	13	**ME**	MME325DO	Industry 4.0: The Smart Manufacturing
7	**EE**	MEE325DG	Intelligent Control Techniques in Electrical Drives	14	**ME**	MME325DQ	Industrial Internet of Things (IIoT)

III SEMESTER M.Tech												
Sl. No.	Course Code	Course Title	Credit Allocation				BoS	Category	CIE Duration (H)	Max Marks CIE	SEE Duration (H)	Max Marks SEE
			L	T/ SDA	P	Total						
1	MBT331TA	New Biopharmaceuticals, Design and Developments	3	1	0	**4**	BT	Theory	1.5	100	3	100
2	MBTX32EX	Professional Elective Courses (NPTEL) (Group-E)	2	0	0	**2**	BT	NPTEL	--	--	2	100
3	MBT433MP	Minor Project	0	0	6	**6**	BT	Project	--	50	--	50
4	MBT434N	Internship	0	0	6	**6**	BT	Internship	1.5	100	3	100
		Total Credits				**18**						

Code	Professional Elective Courses (NPTEL) (Group-E)
MBT332E1	Biological data analysis and visualization with R
MBT332E2	Biostatistics and Design of Experiments
MBT332E3	Introductory Mathematical Methods for Biologists
MBT332E4	Medical Biomaterials

IV SEMESTER M.Tech												
Sl. No.	Course Code	Course Title	Credit Allocation				BoS	Category	CIE Duration (H)	Max Marks CIE	SEE Duration (H)	Max Marks SEE
			L	T/ SDA	P	Total						
1	MBT341FX	Program Specific Courses (NPTEL-Elective) (Group-F)	2	0	0	**2**	BT	NPTEL	--	--	2	100
2	MBT442P	Major Project	0	0	18	**18**	BT	Project	--	100	3	100
Total Credits						**20**						

Code	Program Specific Courses (NPTEL-Elective) (Group-F)
MBT341F1	Traction Engineering
MBT341F2	Food Microbiology for Safe and Sustainable Food Systems
MBT341F3	Biointerface Engineering
MBT341F4	Nanotechnology in Agriculture

SEMESTER: I						
Course Code	:	MMA211TA	**APPLIED MATHEMATICS**	CIE Marks	:	100
Credits L-T-P	:	3-1-0	(*Theory: Common to* MBT, MHT, MMD, MPD, MST)	SEE Marks	:	100
Hours	:	45L+30T+45EL	*(Professional Core Course)*	SEE Duration	:	3 Hours

Unit-I	**09 Hrs**

Statistics:
Method of least squares, fitting of straight line, linearization of nonlinear laws, curve fitting by polynomials, correlation, coefficient of correlation, lines of regression, Spearman rank correlation.

Unit – II	**09 Hrs**

Random variables and Probability Distributions: Random variables-discrete and continuous, probability mass function, probability density function, cumulative distribution function, mean and variance. Discrete distributions - binomial, Poisson distributions. Continuous distributions - exponential and normal distributions.

Unit –III	**09 Hrs**

Sampling and Inferential Statistics: Population and sample mean and proportion of sample, central limit theorem, Sampling distributions - sampling distributions of means, sampling distributions of proportions. Principles of statistical inference, null and alternative hypothesis, Type –I and Type – II errors, level of significance, One tailed and two tailed tests, z- test, t- test.

Unit –IV	**09 Hrs**

Engineering optimization: Engineering applications of optimization, statement of an optimization problem-design vector, design constraints, constraint surface, objective function and objective function surface. Constrained optimization – Lagrange multipliers, multivariable optimization with inequality constraints-Kuhn-Tucker conditions.

Unit –V	**09 Hrs**

Numerical solution of differential equations: Boundary value problems–finite difference method for linear differential equations, shooting method. Finite difference methods for parabolic, elliptic and hyperbolic partial ifferential equations.

Course Outcomes:
After going through this course, the student will be able to:

CO1	:	Explore the fundamental concepts of random variables, probability distributions, sampling, statistics, optimization and numerical methods. **(PO1)**
CO2	:	Apply theoretical concepts of discrete and continuous random variables, probability distributions, sampling, statistics optimization and numerical methods to evaluate the problems of engineering applications. **(PO1, PO4)**
CO3	:	Analyze the solution of the engineering problems solved using appropriate techniques of random variables, probability distributions, sampling theory, statistics optimization and numerical methods. **(PO1, PO4, PO5, PO6)**
CO4	:	Enhance the comprehensive understanding of random variables, probability distributions, sampling theory, statistics optimization and numerical methods gained to demonstrate the problems arising in many practical situations. **(PO1, PO4, PO5, PO6)**

Reference Books

1. Probability & Statistics for Engineers & Scientists, Ronald E. Walpole & Raymond H. Myers, 9th Edition, 2016, Pearson Education, ISBN-13: 978-0134115856.
2. Applied Statistics and Probability for Engineers, Douglas C. Montgomery and George C. Runger, 6th Edition, 2014, John Wiley & Sons, ISBN:13 9781118539712, ISBN (BRV):9781118645062.
3. M K Jain, S. R. K. Iyengar, R. K. Jain; Numerical methods for scientific and engineering computation; New Age International Publishers; 6th Edition; 2012; ISBN-13: 978-81-224-2001-2.
4. Singiresu S. Rao, Engineering Optimization Theory and Practice, New Age International (P) Ltd., 3rd Edition, ISBN: 81-224-1149-5.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks]**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **THREE quizzes** will be conducted (Two regular quizzes and one optional improvement quiz) & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **THREE** tests will be conducted (Two regular tests and one optional improvement test). Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (15) & Phase II (25) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: I						
Course Code	:	MBT312IA	**GENETIC ENGINEERING**	CIE Marks	:	100+50
Credits L-T-P	:	3-0-1		SEE Marks	:	100+50
Hours	:	45L+45EL+30P	*Theory & Practice (Professional Core - 1)*	SEE Durations	:	3 + 3 Hrs

UNIT - I **10 Hrs**

Gene regulation and Genome editing systems: Gene regulation and Operon concept, Constitutive, Inducible and Repressible systems; Operators and Regulatory elements; Positive and negative regulation of operon: lac and trp operon. Gene regulation in eukaryotes: Transcriptional. post transcriptional, translational and post translational levels. RNAi technology: siRNA and miRNA mediated gene silencing, antisense technology. Genome editing systems: Clustered regularly interspaced short palindromic repeats (CRISPR)/Cas systems, Zinc finger nucleases, Transcription activator-like effector nuclease (TALENS), Meganuclease, Base editors and Prime editing. Mechanism of action of synthetic Riboswitches. Identifying genes of interest through genomic studies. Determining the function of an unknown gene, Studies of the transcriptome
and proteome.

UNIT - II **8 Hrs**

Components of rDNA technology: Isolation and purification of DNA (genomic and plasmid) and RNA. Chemical synthesis of DNA: Phosphoramidite method, use of synthesized oligonucleotides. Labelling nucleic acids: Radioactive and non-radioactive, end labelling, nick translation, primer extension. Nucleic acid hybridization, Gel electrophoresis. Restriction enzymes: Types and mechanism of action, and DNA modifying enzymes (Nucleases, Polymerases, Alkaline phosphatase, Polynucleotide kinase and Terminal deoxynucleotidyl transferase), DNA ligases, Synthetic ribozymes.

UNIT - III **9 Hrs**

Host cells, vectors, promoters and Cloning strategies: Prokaryotic and eukaryotic hosts. Cloning and expression vectors, Vectors: plasmid, bacteriophage and other viral vectors, cosmids, Ti plasmid, Ri plasmids, Yeast Episomal Plasmids (YEp), Yeast integrative plasmids (YIp), Yeast replicative plasmids (YRp), Bacmids, Yeast Artificial Chromosome (YAC), Plant expression vectors, Mammalian expression vectors, Gate-way vector, Promoters: Constitutive, inducible and tissue specific. Cloning from mRNA: synthesis of cDNA, cloning cDNA in plasmid vectors, cloning cDNA in bacteriophage vectors. Cloning from genomic DNA: Genomic DNA libraries, preparation of DNA fragments for cloning, ligation, packaging, and amplification of libraries. Cloning large DNA fragments in BAC and YAC vectors.

UNIT – IV **9 Hrs**

Genetic Transformation and Cloning strategies: Genetic transformation and transfection, Alternative DNA delivery methods: Electroporation, microinjection, biolistic. Genetic transformation of microbes (*E.coli*, *Saccharomyces cerevisiae* and *Pichia pastoris*), *Agrobacterium* and virus-mediated genetic transformation of plants, Chloroplast transformation. Production of Marker-free transgenic plants, Transfection of animal cells (Mice): Retroviral, Transgenic and Gene-targeted transgene approach. Cre-loxP recombination system, Knockdown and Conditional knockdown of target gene expression

UNIT - V **9 Hrs**

Selection, Screening, and Analysis of Recombinants: Genetic selection and screening methods: Using chromogenic substrates, Insertional inactivation, Complementation of defined mutation, other genetic selection methods. Screening using nucleic acid hybridization: Nucleic acid probes, Screening clone banks. Screening using PCR, Immunological screening for expressed genes. Analysis of cloned genes: Characterization based on mRNA translation in vitro, Restriction mapping, Blotting techniques (Southern, Northern and Western), DNA sequencing methods.

LABORATORY **30 Hrs**

1. Isolation and purification of genomic DNA from prokaryotic cells.
2. Isolation and purification of genomic DNA from eukaryotic cells.
3. Isolation and purification of plasmid DNA.
4. Isolation and purification of total RNA.
5. Restriction digestion of DNA.
6. Preparation of competent cells of *E.coli* and genetic transformation of E.coli.
7. Constructing recombinant DNA using gene of interest and vector.
8. Agrobacterium mediated genetic transformation of plants.
9. Amplification of DNA fragments using PCR.
10. SDS-PAGE for separation of proteins.

Course Outcomes: After completing the course, the students will be able to:-		
CO1	:	Illustrate and elucidate mechanism of gene regulation in prokaryotes and eukaryotes, and techniques of rDNA technology.
CO2	:	Apply rDNA technology for genetic manipulation of prokaryotes and eukaryotes
CO3	:	Identify and analyze genetically modified organisms and their products.
CO4	:	Design/develop suitable protocol/technique for producing genetically modified organisms or products in living systems, and interpret the results.

Reference Books

1. Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Martin K, Yaffe A, and Amon A, Molecular Cell Biology, 9th edition, W.H. Freeman, 2021, ISBN: 9781319208523.
2. Glick BR and Patten CL, Molecular Biotechnology – Principles and applications of recombinant DNA, 6th Edition, ASM Press, 2022. ISBN-1683673662
3. Brown TA, Gene Cloning and DNA Analysis – An Introduction, 8th Edition, Wiley-Blackwell Science, 2020, ISBN: 978-1-119-64078-3.
4. Clark DP and Pazdernik NJ, Biotechnology, 2nd Edition, Academic Cell, 2015, ISBN-13: 978-0123850157

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) (EL) = 100 marks]**

Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	CIE THEORY TOTAL	**100**

RUBRIC FOR CONTINUOUS INTERNAL EVALUATION (CIE-Lab)

Q.NO.	**CONTENTS**	**MARKS**
1	Conduction of the Experiments & Lab Record	30
2	Open-ended Lab Experiment	10
3	Lab Test	10
	CIE LAB TOTAL	**50**
	MAXIMUM MARKS FOR THE CIE	**150**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	SEE THEORY TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	10
2	Conduction of the Experiments	30
3	Viva	10
	SEE LAB TOTAL	**50**
	MAXIMUM MARKS FOR THE SEE	**150**

SEMESTER: I						
Course Code	:	MBT313IA	**MULTI-OMICS TECHNOLOGY**	CIE Marks	:	100+50
Credits L-T-P	:	3 - 0 - 1		SEE Marks	:	100+50
Hours	:	45L+45EL+30T	Theory & Practice (Professional Core-2)	SEE Durations	:	3 + 3 Hrs

UNIT – I **9Hrs**

Introduction: Introduction to -omics: overview of genome, transcriptome, proteome, metabolome and fluxome. Introduction to sequencing – DNA sequencing methods - Maxam-Gilbert Method, Sanger Dideoxy method, Fluorescence method, shot-gun approach and Microarray based sequencing. Next Generation Sequencing (NGS) and NGS Platforms - Illumina Reverse Dye-Terminator, Ion Torrent Semiconductor sequencing, Pacific Biosciences Single Molecule Real-Time Sequencing and ONT's MinION sequencing. NGS databases – Zenodo, SRA, ENA,SRA and GEO. Accessing and Retrieval of NGS Data - SRA toolkit and Aspera connect. Pathway and metabolome Databases

UNIT – II **9Hrs**

Genome annotation: Computing Needs for NGS – Data storage, transfer, Computing power, Software needs and Bioinformatics Skills. NGS Data Analysis: Base calling and quality score, Data Quality Control and Preprocessing, Reads Mapping – Mapping approaches and algorithms - BWT. Basic sequence alignment algorithms – Needleman and Wunch, Smith and Waterman, BLAST and PSI-BLAST and FASTA. Gene prediction - Extrinsic, Intrinsic Signals. Algorithms - Exon chaining and Hidden Morkov Models.

UNIT - III **9Hrs**

Proteomics: Protein structure and function. Methods of Proteomics: protein identification - two - dimensional electrophoresis (2-DE) and analytical mass spectrometry (MS) techniques, Multidimensional Protein Identification Technology (MudPIT), Mass spectrometry data analysis, Protein sequencing - Edman degradation, mass fingerprinting. Exploring protein structure space: Structure from Sequence - homology, threading, ab initio & molecular dynamics. Detection of Protein-Protein Interactions. Identifying diagnostics with mass spectral methods. Protein microarrays and detection of autoimmune disease. Proteome annotation.

UNIT - IV **9Hrs**

Analytical methods for detecting and quantifying metabolites: Pathway and metabolome databases and Pathways of central and secondary metabolism. Reconstruction of metabolic networks, Stoichiometric matrix. Topological analysis of metabolic networks with Elementary flux modes and/or Extreme pathways, Introduction to Constraint based metabolic modeling and Flux Balance analysis. flux analysis in metabolic engineering and drug target identification.

UNIT – V **9Hrs**

NGS Applications: Whole Genome Sequencing, Exome sequencing, Metagenomics, Transcriptome sequencing, chip Sequencing, smallRNA sequencing, Methylome sequencing, RAD Sequencing, Amplicon sequencing, RRL sequencing, Whole Mitochondrial Genome sequencing and Whole Chloroplast sequencing. NGS in Molecular diagnosis – Case studies related to above applications.

LABORATORY **30Hrs**

1. A. Fetching of DNA, RNA, and Protein sequences from GenBank, EMBL, DDBJ and SwissProt and navigation of NGS data.
   B. Retrieve the structure of macro and micro molecules from PDB, KEGG Drug and Pubchem compound and Navigation of Molecular structures.
2. A. Mass spectrometry data analysis
   B. Search engines for MS protein identification
3. A. Quality checking and Quality controlling of NGS data.
   B. de novo Genome assembly
4. Differential gene expression analysis using transcriptomic data.
5. Network analysis using transcriptomic data.
6. Chip-Seq Analysis.
   A. QTL analysis.
   B. Identification of promoter sequences in the whole genome data
7. Metagenomic analysis and taxonomic profiling
8. A. Metaproteomics by MS/MS
   B. Modeling Alzheimer's Disease Amyloid-Secretase-Pathway
9. A. Gwenom2 annotation
   B. Functional annotation of genomes
10. A. Meta-transcriptomics

Course Outcomes: After going through this course the student will be able to:		
CO1	:	Gain proficiency in utilizing a range of bioinformatics tools and databases for DNA/RNA/Protein sequence, structure and metabolome analysis.
CO2	:	Investigate and apply innovative sequencing technologies and analytical methods to solve complex biological questions hidden in the field multiOmics.
CO3	:	Demonstrate analytical and logical skills acquired from Bioinformatics tools and technologies for the analysis of Big-Data such as genome, proteome and metabolomic data.
CO4	:	Employ bioinformatics tools to design and execute workflows on cloud computing platforms related to computational biology using genome, proteome and metabolomic data.

Reference Books

1. Next-Generation Sequencing Data Analysis By Xinkun Wang, CRC Press. 2023, ISBN: 9781000897197.
2. Mass Spectrometry Data Analysis in Proteomics by Rune Matthiese, Springer New York. 2019, IBN: 9781493997435.
3. Genomics and Proteomics for Clinical Discovery and Development by György Marko-Varga, Springer Netherlands. 2016, ISBN: 9789401792028
4. Metabolic Flux Analysis-Methods and protocols Edited by Jens O. Krömer, Lars K. Nielsen, Lars M. Blank, Springer Publishers, 2016. ISBN: 9781493911707.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component
[20 (Q) + 40 (T) + 40 (EL) = 100 marks]

Sl. No.	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	CIE THEORY TOTAL	**100**

RUBRIC FOR CONTINUOUS INTERNAL EVALUATION (CIE-Lab)		
Q.NO.	**CONTENTS**	**MARKS**
1	Conduction of the Experiments & Lab Record	30
2	Open-ended Lab Experiment	10
3	Lab Test	10
	CIE LAB TOTAL	**50**
	MAXIMUM MARKS FOR THE CIE	**150**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	SEE THEORY TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	10
2	Conduction of the Experiments	30
3	Viva	10
	SEE LAB TOTAL	**50**
	MAXIMUM MARKS FOR THE SEE	**150**

SEMESTER: I						
Course Code		MBT314A1	**BIOMATERIALS AND STEM CELL FOR TISSUE ENGINEERING**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-A)*	SEE Durations	:	3 Hrs

UNIT - I **09 Hrs**

Introduction and importance of biomaterials: Types of biomaterials: Metallic, ceramic, polymeric and composite biomaterials. Classification according to physiological response of biomaterials: bioinert, bioactive and bioresorbable biomaterials; Surface modifications; Surface analysis; Surface-protein interactions; Material-cell interactions: biocompatibility and rejection; Implants and infection.

Applications of biomaterials in cardiology, nephrology, ophthalmology, dentistry and orthopaedics; Wound healing and dressing materials, skin substitutes and sutures, Functional Tissue Engineering and drug delivery systems, Biosensing and Diagnostics.

UNIT - II **09 Hrs**

Growth and Regeneration: Stem Cells classifications, sources and Properties; Cell culture methods, Cell isolation, Selection, Maintenance of primary and early passage cultures. Differentiation and Clinical potential of stem cells: Organ and tissue regeneration. Cord blood transplantation, Donor selection, HLA matching, patient selection, peripheral blood and Hematopoietic Stem Cell Disorders, Stem cell Techniques: fluorescence activated cell sorting (FACS), time lapse video, green fluorescent protein tagging.

UNIT - III **09 Hrs**

Therapeutics and tissue engineering strategies: Founder zones in plants roots and shoot meristems of higher plants. Skeletal muscle stem cells; Mammary, Intestinal, Keratinocyte stem cells of cornea, Skin and hair follicles, Genetic modification of stem cells, Stem Cell Systems and Bioengineering, Stem cell technology, Tumor stem cells.

UNIT - IV **09 Hrs**

Tissue regeneration and Differentiations: Morphogenesis and tissue engineering-gene expression, cell determination and differentiation. In vitro control of tissue development: In vitro culture parameters, growth factors, mechanobiology, tissue development and organ engineering. In vivo synthesis of Tissue and Organs. Mesenchymal stem cells (MSCs) and adipose derived stem cells (ASCs). Therapeutic strategy for repairing the injured spinal cord using stem cells. Wound and Disc repair using stem cells. Engineering of tissues: cartilage, bone and skin. Biomaterials in tissue engineering.

UNIT - V **09 Hrs**

Stem Cells in Drug Discovery and Ethical Issues: Target identification, manipulating differentiation pathways, stem cell therapy Vs cell protection, stem cell in cellular assays for screening: Stem cell based drug discovery, drug screening and toxicology. Tissue engineering applications: Production of part and complete organs. Stem cell policy and ethics, stem cell research: Hype, hope and controversy.

Course Outcomes: After going through this course the student will be able to:

CO1	:	Understand the importance of stem cell, characteristics and tissue functions for specialized applications
CO2	:	Compare various kinds of stem cells and tissues used for regeneration purposes.
CO3	:	Interpret the methods used in organ regeneration.
CO4	:	Apply techniques for growth of stem cells, and repairing various kinds of tissues

Reference Books

1. Song Li, Nicolas L' Heureux and Jennifer Elisseeff, Stem cell and Tissue Engineering, 1st edition, World Scientific Publications, 2021, ISBN-13: 978-981-4317-05-04
2. R Lanza, Langer R and Vacanti J, Principles of Tissue Engineering, 5th edition, Elsevier, 2023. ISBN: 9780128184226
3. John P. Fisher, A G Mikos and Joseph D Bronzino, Tissue Engineering. 1st edition, CRC Press. 2023. ISBN: 9780367389055
4. JD Bronzino, Taylor and Francis, Tissue Engineering and Artificial organs, 4th edition, CRC Press, 2023, ISBN: 0849321239.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: I						
Course Code	:	MBT314A2	**HUMAN DISEASES AND DIAGNOSTIC TECHNOLOGY**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-A)*	SEE Durations	:	3 Hrs

UNIT – I **09 Hrs**

Introduction to Diseases: Classification of diseases: Infectious, genetic, metabolic, and degenerative, Overview of diagnostics in healthcare. Infectious Diseases; Pathogens: Bacteria, viruses, fungi. Immune system response to infections, Diagnostic methods: Cultures, serology, molecular diagnostics (PCR) Genetic Disorders; Chromosomal abnormalities: Down syndrome, Turner syndrome Diagnostic techniques: Karyotyping, genetic screening, gene sequencing.

UNIT – II **09 Hrs**

Cardiovascular Diseases: Coronary artery disease, hypertension, heart failure. Risk factors and prevention strategies Diagnostics: ECG, echocardiography, angiography, cardiac biomarkers.
Respiratory Diseases; Chronic obstructive pulmonary disease (COPD), asthma, tuberculosis Diagnostics: Pulmonary function tests, chest X-rays, CT scans.

UNIT – III **09 Hrs**

Neurological Diseases: Alzheimer's disease, Parkinson's disease, epilepsy. Diagnostics: MRI, CT scans, EEG, lumbar puncture. Endocrine Disorders; Diabetes mellitus, thyroid disorders, adrenal disorders, Hormonal imbalances and metabolic consequences, Diagnostics: Blood glucose, HbA1c, TSH. **Renal Diseases;** Acute kidney injury, chronic kidney disease, glomerulonephritis Diagnostics: Blood urea nitrogen (BUN), serum creatinine, urinalysis.

UNIT – IV **09 Hrs**

Haematological Disorders: Anaemia, leukemia, lymphoma, hemophilia Blood cell morphology and function, Diagnostics: Complete blood count (CBC), bone marrow biopsy. Autoimmune Diseases; Rheumatoid arthritis, lupus, multiple sclerosis, Mechanisms of autoimmunity, Diagnostics: Autoantibody testing, rheumatoid factor, ANA test Dermatological Disorders; Psoriasis, eczema, skin cancer, infections of skin.

UNIT – V **09 Hrs**

Oncology: Introduction to oncology, Definition and types of cancer, Causes and risk factors for cancer (genetic, environmental, lifestyle), Mechanisms of carcinogenesis, Oncogenes, tumor suppressor genes, Classification of cancers based on tissue origin (carcinomas, sarcomas, lymphomas, leukemias), Cancer grading and staging (TNM classification system), Diagnosis of Cancer; Signs and symptoms of common cancers, Diagnostic techniques: Imaging (CT, MRI, PET, X-rays), Biopsy and histopathology, Tumor markers and laboratory tests, Molecular diagnostic techniques (next-generation sequencing, PCR, etc.).

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Understanding etiology of diseases.
CO2	:	Apply the knowledge of principles of pathophysiology of diseases.
CO3	:	Analyze Diagnostic Methods for human diseases affecting organ systems.
CO4	:	Evaluate disease Impact on Body Systems and Interpret Diagnostic Results

Reference Books

1. Brian R. Walker,Nicki R. College,Stuart H. Ralston Ian Penman, Davidson's Principles and Practice of Medicine is the 24th edition, Elsevioer 2023.Print ISBN: 9780702083471 eText ISBN: 9780702083501
2. Park's Textbook of Preventive and Social Medicine 26th edition JAYPEE Brothers ISBN: 9789382219163
3. Harsh Mohan Textbook of Pathology 8th edition, Jaypee Publishers 2019 ISBN 9789352705474,
4. Richard A. McPherson, Matthew R. Pincus Clinical Diagnosis and Management by Laboratory Methods (25th Edition) ISBN: 9780323530453

Scheme of Continuous Internal Evaluation (CIE): 20 + 40 + 40 = 100

QUIZZES: Quizzes will be conducted in online/offline mode. Two quizzes will be conducted & Each Quiz will be evaluated for 10 Marks. The sum of two quizzes will be the Final Quiz marks.

TESTS: Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). Two tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. Final test marks will be reduced to 40 Marks.

EXPERIENTIAL LEARNING: Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning and Program specific requirements (15), Video based seminar/presentation/demonstration (25) adding upto 40 marks.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: I						
Course Code	:	MBT314A3	**ADVANCED DRUG DESIGN AND DISCOVERY**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-A)*	SEE Durations	:	3 Hrs

UNIT - I **9 Hrs**

***Advanced Drug Discovery and Development Process*:** Overview of modern drug discovery pipelines, integrating AI/ML in drug discovery, advanced methods for compound searching.*Target Identification & Characterization*: Multi-omics data integration for target identification, target validation using CRISPR and RNAi techniques, structural biology approaches for target characterization. *Study of Molecular Interactions*: High-throughput molecular docking techniques, introduction to AI-assisted docking. *ADMET Studies*: In silico methods for advanced ADMET profiling, predictive toxicology using machine learning models. *Study of Drug Resistance*: Mechanistic insights into drug resistance, strategies for overcoming drug resistance using structure- based approaches. *Drug Design Process for Known Protein Target*: Structure-based drug design, introduction to fragment-based drug discovery, free energy perturbation for hit optimization. *Drug Design Process for Unknown Protein Target*: Ligand-based drug design using machine learning, scaffold hopping for lead identification.

UNIT - II **9 Hrs**

Structure Generation, Retrieval, and Visualization: Advanced structure generation techniques, structure retrieval from curated databases. Homology Modeling: Constructing initial models with AI/ML refinement tools, using AlphaFold and other AI-driven modeling platforms. Model Evaluation: Advanced model evaluation techniques, including Ramachandran plot analysis, ProSA, and MolProbity.

Conformation Generation and Bioactive Conformations: Use of machine learning in deriving bioactive conformations. Molecular Superposition and Alignment: Introduction to 3D-QSAR alignment techniques, advanced methods for pharmacophoric pattern generation and receptor mapping. Rational Drug Design & Chemical Intuition: Role of AI in enhancing chemical intuition, limitations, and considerations of AI in rational drug design.

UNIT – III **9 Hrs**

Molecular Mechanics and Docking: Advanced force fields (e.g., OPLS4, CHARMM36m), machine-learning-based scoring functions in docking. *Study of Protein Folding*: AI-enhanced algorithms for protein folding prediction, detailed conformation analysis using advanced sampling methods. *Docking*: Use of cloud-based docking platforms, ensemble docking for increased accuracy, flexible docking methods. *Pharmacophore Models*: AI-assisted pharmacophore model generation, pharmacophore-guided compound library screening. *Active Site Analysis*: Techniques for identifying allosteric binding sites and cryptic pockets using computational methods.

UNIT – IV **9 Hrs**

Molecular Dynamic Simulations: Use of enhanced sampling techniques (e.g., metadynamics, accelerated MD) for exploring conformational space. *orce Field Development*: Development and validation of custom force fields, role of polarizable force fields in simulation accuracy. *Thermodynamic Properties*: Advanced free energy calculations using MMGBSA and FEP+, heat capacity estimation using advanced statistical methods. *Applications and Case Studies*: Case studies focusing on the use of MD simulations in drug design, such as binding affinity prediction and conformational changes in disease-related proteins.

UNIT - V **9 Hrs**

QSAR & Advanced Computational Techniques: *Conventional QSAR vs. 3D-QSAR*: AI-driven descriptor generation, multi-task learning approaches for QSAR. *3D- QSAR*: Use of machine learning algorithms in 3D-QSAR model building, validation techniques for model robustness. *Quantum Mechanics in Drug Design*: Introduction to DFT calculations for drug design, hybrid quantum mechanics/molecular mechanics (QM/MM) approaches. *Advanced ADMET & Toxicity Studies*: Predictive models for off-target interactions and adverse drug reactions. *New Lead Discovery Strategies*: AI-driven de novo drug design, reinforcement learning in lead optimization. *Current Practices in CADD*: Role of AI in CADD, case studies of successful AI-driven drug discovery, challenges, and future directions. *Management of CADD Groups*: Strategies for integrating computational groups within drug discovery teams, adapting to emerging technologies.

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Demonstrate an in-depth understanding of physical, chemical, and biological properties of pharmacological compounds.

CO2	:	Apply advanced drug design methods and AI/ML approaches for screening and identifying new targets and compounds.
CO3	:	Evaluate the drug-likeness and potential toxicology of compounds using predictive models.
CO4	:	Develop innovative drug design strategies, focusing on IP generation and commercialization of novel compounds.

Reference Books

1. Kristian Stromgaard, Povl Krogsgaard-Larsen, Ulf Madsen,Textbook of Drug Design and Discovery, 5th Edition,Taylor and Francis, 2017, ISBN 9781032339948
2. Mohane S. Coumar, Molecular Docking for Computer-Aided Drug Design Fundamentals, Techniques, Resources and Applications, Academic Press, 1st edition, 2021, ISBN 978-0-12-822312-3
3. Kun Zhou, Bo Liu, Molecular Dynamics Simulation, Fundamentals and Applications, Elsevier,1st edition, 2022, ISBN: 9780128164198
4. Kunal Roy Supratik Kar Rudra Narayan Das, Understanding the Basics of QSAR for Applications in Pharmaceutical Sciences and Risk Assessment, 1st edition, Academic Press, 2015, ISBN: 9780128016336

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**

Sl.No.	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)

Q.NO.	CONTENTS	MARKS
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: I						
Course Code	:	MBT214A4	**FOOD TECHNOLOGY**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives)(Group-A)*	SEE Durations	:	3 Hrs

UNIT – I	**9 Hrs**
Properties of foods and processing theory: Properties of liquids, solids and gases, Fluid flow through fluidized bed, Mechanisms of heat transfer, Sources of heat and methods of application to foods, Energy conservation Effect of heat on micro-organisms, Effect of heat on nutritional and sensory characteristics, Water activity, Effects of processing on sensory characteristics of foods, Effects of processing on nutritional properties, Food safety, good manufacturing practice and quality assurance	
UNIT – II	**9 Hrs**
Ambient-temperature processing: Raw material preparation: Cleaning, Sorting, grading, peeling. Size reduction: Size reduction of solid and liquid foods: theory, equipment and effects on food. Mixing and forming. separation and concentration of food components, Processing using electric fields: high hydrostatic pressure, light or ultrasound, irradiation: theory, equipment and effect on food.	
UNIT – III	**9 Hrs**
Processing by application of heat (theory, equipment and effect on foods): Heat processing using steam or water, Blanching, Pasteurization, Heat sterilization, Extrusion, Heat processing using hot air(theory, equipment and effect on foods): Dehydration, Baking and roasting, Heat processing by direct and radiated energy: Dielectric, ohmic and infrared heating. Heat processing using hot oils: theory equipment and effects on food of frying	
UNIT – IV	**9 Hrs**
Processing by the removal of heat: Chilling, Controlled- or modified-atmosphere storage and packaging, Freezing and concentration. Post-processing operations: coating or enrobing, Packaging: theory and types of packaging materials, Printing, Interactions between packaging and foods. Environmental considerations. Filling and sealing of containers: Rigid and semi-rigid containers, flexible containers, Types of sealer, Shrink-wrapping and stretch-wrapping, Tamper-evident packaging, Labelling, Materials handling, storage and distribution.	
UNIT – V	**9 Hrs**
Prebiotics, probiotics and nutraceuticals: Food Pyramid, Concept of prebiotics and probiotics - principle, mechanism and applications of probiotics, prebiotics Synbiotics for maintaining good health. Source of omega - 3 fatty acids, formulations, bioavailability, bioequivalence, Commercialization and Potential of Nutrigenetics and Nutrigenomics	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Remember and apply the properties of food during processing of food
CO2	:	Know the application of biotechnology for food preservation and food production with improved nutritional benefits.
CO3	:	Acquire and apply various food processing techniques to increase the nutritional content and shelf life of food.
CO4	:	Evaluate and analyze the current ongoing research in nutraceuticals.

Reference Books

1. Food Processing Technology: Principles and Practice, Fellows, P.J, Woodhead Publishing limited, Cambridge, 2nd edition, 2009. ISBN 978-1-84569-216-2
2. Introduction to Food Engineering,R. Paul Singh and Dennis R. Heldman, Academic Press, Elsevier, 5th ed., 2013 ISBN 9780123985309
3. Food Process Engineering Operations, George D. Saravacos and Zacharias B. Maroulis,, 1st ed. 2011, CRC press, Taylor and Francis, ISBN- 13: 978-1-4200-8354-5
4. Nutrigenomics and Nutrigenetics in Functional Foods and Personalized Nutrition, Lynnette R. Ferguson, 2013
5. CRC Press ISBN 9781439876800

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: I						
Course Code	:	MBT415SL	**BIOANALYTICAL LABORATORY**	CIE Marks	:	50
Credits L-T-P	:	0-0-2		SEE Marks	:	50
Hours	:	30 P	*(Skill Laboratory)*	SEE Durations	:	3 Hrs
Content						**30 Hrs**

1. Study of Gas Chromatography–Mass Spectrophotometer (GC-MS)

- Configuring the structural components of GC-MS
- Characterization of Lead compounds from Microbial / Plant samples
- Interpretation of GC-MS data.

2. Exploring COE for Materials and Fabrication: Scanning Electron Microscopy (SEM) and FTIR

- Comprehend the structural and functional component of SEM and FTIR
- Characterization of Green synthesized nanoparticles

3. Exploring COE for Computational Genomics

- Molecular Docking
- Ligand docking and protein – Protein docking
- Virtual screening techniques for drug discovery
- Homology modelling for protein structure prediction

4. **Pharmcophore modelling and QSAR analysis**

- Pharmacophore Searching to identify compounds that match a specific pharmacophore model
- ADMET Test

Course Outcomes:

After going through this course, the students will be able to:

CO1	:	Apply the knowledge of various principles in day to day life the basic principles and mechanism of bioanalytics
CO2	:	Analyze the biomolecules using various mechanism of bioanalytics
CO3	:	Sustain and comprehend various principle for the varied application
CO4	:	Adapt and inculcate to the fast changing technology for better future

Reference Books

1. Keith Wilson and John Walker, Principles and techniques of biochemistry and molecular biology.7th Edition, Cambridge University Press, Cambridge, UK., 2009,ISBN:978-0-521-51635-8
2. Ghosal, Sabari and Avasthi Anupama Sharma, Fundamentals of Bioanalytical Techniques and Instrumentation, 2nd edition, PHI Learning Pvt. Ltd., 2018, 938747240X, 789387472402
3. Rajan Katoch, Analytical Techniques in Biochemistry and Molecular Biology, 1st edition, Springer, 2011, ISBN 978-1-4419-9784-5
4. Vasudevan Ramesh, Biomolecular and Bioanalytical Techniques, 1st edition, Wiley, 2019, , ISBN: 9781119483960

Scheme of Continuous Internal Evaluation (CIE- Laboratory) : Only LAB Course 30 + 10 + 10 = 50. The Laboratory session is held every week as per the timetable and the performance of the student is evaluated in every session. The average of marks over number of experiments conducted over the weeks is considered for 30 Marks i.e (Lab Report, Observation & Analysis). The students are encouraged to implement additional innovative experiments in the lab (10 marks). At the end of the semester a test is conducted for 10 Marks (Lab Test). This adds to 50 Marks.

Scheme of Semester End Examination (SEE- Laboratory) : Only LAB Course 40 + 10 =50. Students will be evaluated for Write-up, Experimental Setup, Experiment Conduction with Results, Analysis & Discussions for 40 Marks and Viva will be conducted for 10 Marks adding to 50 Marks.

RUBRIC FOR CONTINUOUS INTERNAL EVALUATION (CIE-Lab)		
1	Conduction of the Experiments & Lab Record	30
2	Open-ended Lab Experiment	10
3	Lab Test	10
	MAXIMUM MARKS FOR THE CIE	**50**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	10
2	Conduction of the Experiments & Results	30
3	Viva	10
	MAXIMUM MARKS FOR THE SEE	**50**

SEMESTER: I						
Course Code	:	HSS116L	**Technical English (Common to all Programs)**	CIE Marks	:	50
Credits L-T-P	:	0-0-1	**Online English Laboratory Course**	SEE Marks	:	50
Hours	:	30P	Humanities and Social Sciences	SEE Duration	:	2 Hours

Unit-I	**10 Hrs**
The Basics. Business Documents, Questions, and the Technical Pursuit. Engineering Concepts and Complexity; The Future Tense for Technical Work. White Papers; Modifiers and Qualifiers.	
Unit – II	**10 Hrs**
Making Recommendations; Interpreting Data, Ethical Persuasion for Technical Projects; Cause and Effect; Calls for Proposals. Technical Complexity in Communication. Numbers, Plain English, Jargon, and Technical Terms, Active and Passive Structures.	
Unit –III	**10 Hrs**
Organization Needs; Seeing the Big Picture; Negotiating. Audience Needs and Assessment; Standards versus White Papers; Objectivity, communicating within Expected Genres; Identifying Trustworthy Sources or Bias in. A Review of Major Course Takeaways	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Demonstrate clarity and precision in technical communication by structuring information effectively, balancing technical terms with plain English, and adapting to diverse audiences.
CO2	:	Analyze and produce professional documents, such as white papers, business proposals, and reports, while applying ethical persuasion, data interpretation, and evidence-based reasoning.
CO3	**:**	Evaluate and refine communication strategies by assessing audience needs, recognizing trustworthy sources, and navigating organizational and technical complexities.
CO4	:	Apply critical thinking and negotiation skills to align communication with organizational goals, anticipate future challenges, and support informed decision-making.

References

1. IEEE – EBSCO Technical English for Professionals – Online platform.
2. Valerie Lambert, Elaine Murray, English for Work – Everyday Technical English, Pearson Education, 2003, ISBN- 0 582 53963 3.
3. David Bonamy, Christpher Jacques, Technical English – First Course Book, Pearson Education, 2008.
4. S Sumant. Technical English I, The McGraw Hill, 2011, ISBN -978 81 8209 308 9.

Assessment and Evaluation Pattern (Online Mode)		
Weightage	**50%**	**50%**
Test – I	Each test will be conducted for 50 marks adding to 100 marks. Final test marks will be reduced to 40 marks	
Test – II		
Experiential Learning		
Communication Skills- Activity based test – Script writing, Essay Writing, Role plays. Any other activity that enhances the Communication skills. The students will be assigned with a topic by the faculty handling the batch. The students can either prepare a presentation/write essay/role play etc. for the duration (4-5 minutes per student). **Parameters for evaluation of the Presentation** a. Clarity in the presentation/ Speaking/Presentation skills. b. Concept / Subject on which the drama is enacted/ scripted	10 Marks	**Final assessment will be conducted for 50 marks**
Maximum Marks	50 Marks	**50 Marks**
Total marks for the course	**50**	**50**

SEMESTER: II						
Course Code	:	MBT321IA	**INDUSTRIAL BIOTECHNOLOGY**	CIE Marks	:	100+50
Credits L-T-P	:	3-0-1		SEE Marks	:	100+50
Hours	:	45L+45EL+30P	*Theory & Practice (Professional Core -3)*	SEE Durations	:	3 + 3 Hrs

UNIT – I	**9 Hrs**
Plant tissue culture techniques: Dedifferentiation and redifferentiation, Organogenesis and somatic embryogenesis, Gene regulation during somatic embryogenesis, Micropropagation of Ornamental (Anthurium and Orchids), horticultural (Banana), and medicinal (*Rauwolfia serpentina*) plants. Production of somatic hybrids and somaclonal variants. Production of secondary metabolites from callus, cell suspension culture, and Hairy root cultures of medicinal plants. Enhanced production of secondary metabolites by using Biotic and abiotic elicitors.	

UNIT – II	**9 Hrs**
Production of recombinant products/traits in transgenic plants: Molecular farming/pharming- Amino acids (methionine), Lipids (omega-3 and omega-6 fatty acids), Vitamins (β-Carotene), Iron, Starch (α-amylase and glucose isomerase in potato), Antibodies (IgG antibodies), Edible Vaccines (Cholera), bioplastics (PHB), Genetic manipulation of fruit ripening (Tomato), and Flower pigmentation (Petunia). Production of insect (Cotton), fungal, bacterial, and viral resistant plants. Production of abiotic (Drought and saline) tolerant plants. RNAi and plant genome editing systems for crop improvement.	

UNIT – III	**9 Hrs**
Microbial production of natural/recombinant products: recombinant enzymes: Restriction endonucleases, Cellulase, Amylase, Lipase, and Alginate Lyase. Amino acids (L-Glutamic acid), Antibiotics (Undecylprodigiosin, 7-aminodeacetoxycephalospopranic acid), Biopolymers (recombinant Xanthan gum), Spider silk protein, Citric acid, and Insulin. Vaccines: Inactivated vaccine (SARS-CoV-2 Virus), Attenuated vaccine (Cholera), Viral vector vaccine (SARS-CoV-2 Virus), Peptide Vaccine (Malaria), Subunit Vaccines (Herpes Simplex Virus), DNA (*Shigella flexneri*) and mRNA Vaccine (SARS-CoV-2 Virus). Production of Beer, Wine, and Biofuel (Ethanol and Methane).	

UNIT – IV	**9 Hrs**
Animal cell culture techniques: Primary culture, adult and embryonic stem cells, hybridoma technology for monoclonal antibody production, Production of recombinant biopharmaceuticals in Milk [Cystic fibrosis transmembrane regulator (CFTR)], recombinant antibodies in Chicken Eggs, Increased muscle mass in Transgenic mice, High levels of omega-6- fatty acids, improving growth rate (Fish), Cloning Livestock by Nuclear Transfer (Dolly), Disease (Prion diseases)-Resistant Livestock, Gene therapy, Knockout mice model for human genetic disease research	

UNIT – V	**9 Hrs**
Regulating the use of Biotechnology: Laboratory safety, risk assessment, standard operating systems, biohazards, bioethics and validation, issues and concerns, biosafety, and societal and ethical aspects of genetically modified foods and crops. Regulating recombinant DNA technology, and food & food ingredients, Patenting biotechnology.	

LABORATORY	**30 Hrs**
1. Micropropagation of Ornamental/horticultural/medicinal plants. 2. Initiation of cell suspension culture using explants of medicinal plants. 3. Elicitation of secondary metabolites in callus using various elicitors. 4. Extraction of secondary metabolites from callus culture and its estimation. 5. Isolation of antibiotic producing bacterial and fungal species from soil sample. 6. Production of pectinase from microbial cultures and estimation of its activity. 7. Production of cellulase from microbial cultures and estimation of its activity. 8. Production of proteases from microbes and estimation of its activity. 9. Bioethanol from agricultural/horticultural wastes. 10. Cell viability study by trypan blue dye.	

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Illustrate and explain the culture techniques used for microbes, plants, and animals.
CO2	:	Apply modern tools for large-scale production of organisms/products and interpret the results.
CO3	:	Differentiate, select, and evaluate the organisms/products produced in prokaryotic and eukaryotic organisms.
CO4	:	Design protocols for the production of compounds in biological systems and interpret the results.

Reference Books

1. Glick BR and Patten CL, Molecular Biotechnology – Principles and applications of recombinant DNA, 6th Edition, ASM Press, 2022. ISBN-1683673662
2. Glazer AN and Nikaido H, Microbial Biotechnology, 2nd Edition, Cambridge University Press, 2008, ISBN-13: 978-052179673
3. Clark DP, and Nanette J. Pazdernik, Biotechnology, Academic Cell, 2 edition, 2016, ISBN-13: 978-0123850157.
4. Harry Johnson, Animal Cell Biotechnology,1st edition, States Academic Press, 2022, ISBN-13: 978-16 1639890484.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks]**

Sl.No.	COMPONENTS	MARK S
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	CIE THEORY TOTAL	**100**

RUBRIC FOR CONTINUOUS INTERNAL EVALUATION (CIE-Lab)

Q.NO.	CONTENTS	MARK S
1	Conduction of the Experiments & Lab Record	30
2	Open-ended Lab Experiment	10
3	Lab Test	10
	CIE LAB TOTAL	**50**
	MAXIMUM MARKS FOR THE CIE	**150**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	SEE THEORY TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	10
2	Conduction of the Experiments	30
3	Viva	10
	SEE LAB TOTAL	**50**
	MAXIMUM MARKS FOR THE SEE	**150**

SEMESTER: II

Course Code	:	MBT322IA	**BIOPROCESS ENGINEERING**	CIE Marks	:	100+50
Credits L-T-P	:	3- 0 - 0		SEE Marks	:	100+50
Hours	:	45L+45EL+30P	*Theory & Practice (Professional Core-4)*	SEE Duration	:	3 + 3 Hrs

UNIT – I **9 Hrs**

Homogeneous reactions: Basic reaction theory, calculation of reaction rates from experimental data. General reaction kinetics from biological systems. Yield in cell culture, cell growth kinetics, Production kinetics in cell culture, Kinetics of substrate uptake in cell culture, determining cell kinetics parameters from batch data, effect of maintenance on yields, kinetics of cell death, numericals

UNIT – II **9 Hrs**

Reaction Engineering: Bioreactor Configurations: stirred tank, bubble column, airlift reactor, packed bed, trickle bed. practical considerations for bioreactor construction: Aseptic operation, fermenter inoculation and sampling, materials of construction, impeller baffle and sparger design, evaporation control. Monitoring and control of bioreactors: Fermentation monitoring, measurement analysis, fault analysis, process modelling, feedback control. Applications of artificial intelligence in bioprocess control

UNIT – III **9 Hrs**

Ideal reactor operation: batch operation of a mixed reactor, enzyme reaction, cell culture in batch reactor, batch culture time and total time for batch reaction cycle.fed batch operation, CSTR with enzyme reaction, immobilized enzyme reaction in a CSTR. CHEMOSTAT with immobilized cell. PFR and enzyme reaction in enzyme reaction.

UNIT – IV **9 Hrs**

Downstream processing: Recovery of intracellular and extracellular products, cell disruption techniques, Process design criteria for low volume high value products and high volume low value products. Process economics: cost cutting strategies, costing for purification of a by-product.

UNIT – V **9 Hrs**

Chromatography: Introduction to chromatography, Types of chromatography: -Affinity chromatography, mechanism. Membrane chromatography, types of membranes used in bioprocess, compatibility of membranes, biofouling of membranes, concentration polarization and methods of control. Membrane chromatography modules and mechanism and scale-up techniques for purification of biomolecules, Electrochromatography, Simulated moving bed chromatography.

LABORATORY **30 Hrs**

1. Production of amylase and estimation of its activity.
2. Production and estimation of of citric acid
3. Production and estimation of of lipase
4. Production of spirulina
5. Centrifugation studies during the settling of yeast cells
6. Extraction of protein/phycocyanin from Spirulina and its estimation
7. To carry out bulk precipitation of protein/enzyme from given suspension (ex: yeast cells) using ammonium sulfate and find the % cut of ammonium sulfate where the protein is highest precipitated
8. To determine the constants of the Freundlich equation by adsorbing protein on adsorbent.
9. To determine the partition coefficient and yield of total protein present in yeast cells using Polyethylene Glycol (PEG) 4000 and potassium phosphate system in single stage.
10. To determine the rate of drying for the given sample in a vacuum tray dryer.

Course Outcomes: After going through this course the student will be able to:		
CO1	:	Remember the basic principles of fluid mechanics
CO2	:	Apply the principles of heat transfer to predict heat transfer coefficients and for the design of equipment's
CO3	:	Analyze and solve the problems of mass transfer
CO4	:	Evaluate the enthalpy and entropy changes calculations, energy and mass balance in biological Reactions

Reference Books

1. Michael Shuler and Fikret Khargi, Bioprocess Engineering, Basic Concepts, 2nd Edition, Prentice Hall, 2015, ISBN:978-9332549371
2. P.M. Doran; Bioprocess Engineering Principles; 2nd ed, Academic Press; 2012, ISBN:978012220851
3. Harrison R.G. Todd P. Rudge S.R. and D.P. Petrides, Bioseparations Science and Engineering, 2nd edition, Oxford University Press, 2015, ISBN: 9780195391817
4. Mukesh Doble, Principles of Downstream Processing in Biological and Chemical Processes, 1st edition. CRC Press, Taylor & Francis group, 2015, ISBN 9781771881401

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks]**

Sl.No.	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	CIE THEORY TOTAL	**100**

RUBRIC FOR CONTINUOUS INTERNAL EVALUATION (CIE-Lab)		
Q.NO.	**CONTENTS**	**MARKS**
1	Conduction of the Experiments & Lab Record	30
2	Open-ended Lab Experiment	10
3	Lab Test	10
	CIE LAB TOTAL	**50**
	MAXIMUM MARKS FOR THE CIE	**150**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	SEE THEORY TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Lab)		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	10
2	Conduction of the Experiments	30
3	Viva	10
	SEE LAB TOTAL	**50**
	MAXIMUM MARKS FOR THE SEE	**150**

SEMESTER: II						
Course Code	:	MBT223B1	**FERMENTATION & ENZYME TECHNOLOGY**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-B)*	SEE Durations	:	3 Hrs

UNIT - I — **10 Hrs**

Introduction: Fermentation as a Biochemical process, Microbial biomass, Enzymes, Metabolites recombinant products, General flow sheet for microbial fermentation. Isolation of industrially important microorganisms, preservation techniques of microbial cultures, Mode of fermentation operation: batch, fed batch and Continuous.
Fermenter and Instrumentation: Basic structure of fermenter, body construction and space requirements. Description of different parts of fermenter, impellers, types of fermenters-semi- automatic and automatic fermenters.
Process Control: Instruments for the fermentation process: flow rate, temperature, pH, Dissolved oxygen and pressure measurements. Foam sensing and control. Online analysis for the substrate and biomass estimation. Computer based data acquisition-SCADA. Scale-up of fermentation process

UNIT – II — **9 Hrs**

Enzymes and Enzyme Kinetics
Nomenclature and classification, Application of enzymes in process industries and health care. Enzymes as biocatalysts: advantages and disadvantages over chemical catalysts and characteristics, microbial production and purification of enzymes Assay of enzyme activity and specific activity.
Factors affecting the enzyme activity- Concentration, pH and temperature. Kinetics of a single-substrate enzyme catalysed reaction, Michealis-Menten Equation, Km, Vmax, L.B Plot, Turnover number, Kcat. Kinetics of Enzyme Inhibition. Kinetics Allosteric enzymes.

UNIT – III — **9 Hrs**

Enzyme Immobilization: Methods, Activity and kinetics of immobilized enzymes; Applications of immobilized enzyme technology. Enzyme sensors for clinical analysis, therapeutic medicine, Environmental applications. Economic argument for immobilization, therapeutic, diagnostic and industrial applications of enzyme inhibitors. Large scale extraction and purification of enzymes.

UNIT – IV — **9 Hrs**

Industrial Applications of Enzymes: in medicine, textile, leather, detergent, paper, bakery, dairy industry, beverage and fruit processing, food processing and preservation, clinical applications of enzyme estimation. Novel enzymes and its application in current research, Enzymes in drug discovery.

UNIT – V — **8 Hrs**

Case studies of Fermentation Processes: Understanding of fermentation Process economics, Beer fermentation process, Streptomycin production, Vitamin B12 production, Lipase enzyme production, Monoclonal Antibodies production and Recombinant human insulin production. Effluent treatment methods for fermentation industries.

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Understand the importance of fermentation and enzymes
CO2	:	Apply instrumentation principles and properties in enzyme Kinetics
CO3	:	Analyze the fermentation applications and the use of enzymes in industries
CO4	:	Interpret the application of fermentation processes in industries

Reference Books

1. S. Shanmugam. Enzyme Technology, 1st Edition,I. K. International Pvt Ltd,2009, ISBN: 9789380026053

2. Klaus Buchholz, Uwe Theo Bornscheuer, and Volker Kasche. Biocatalysts and Enzyme Technology, 2nd edition,Wiley,2012,ISBN: 978-3-527-32989-2

3. Prasad Nooralabettu Krishna. Enzyme Technology: Pace maker of Biotechnology,1st edition, PHI Learning Pvt., 2011, ISBN:9788120342392

4.P. Stanbury, A Whitaker. and S. Hall. Principles of Fermentation Technology; Aditya Books Pvt Ltd. New Delhi; 2ndedn; 2003. ISBN: 8185353425.

Scheme of Continuous Internal Evaluation (CIE): 20 + 40 + 40 = 100

QUIZZES: Quizzes will be conducted in online/offline mode. Two quizzes will be conducted & Each Quiz will be evaluated for 10 Marks. The sum of two quizzes will be the Final Quiz marks.

TESTS: Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). Two tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. Final test marks will be reduced to 40 Marks.

EXPERIENTIAL LEARNING: Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning and Program specific requirements (15), Video based seminar/presentation/demonstration (25) adding upto 40 marks.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MBT323B2	**AGRICULTURE BIOTECHNOLOGY FOR ENHANCED CROP YIELD**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-B)*	SEE Durations	:	3 Hrs

UNIT – I **9 Hrs**

History and Scope: Tissue culture as a tool in crop improvement: Introduction to tissue culture, sterilization of field grown tissues, callus induction, initiation of suspension cultures, role of hormones in plant morphogenesis, regeneration of shoots and roots from callus cultures, secondary plant products and their methods of production, Synthetic seeds. Germplasm preservation.

UNIT – II **9 Hrs**

Concepts and scope of Agricultural Biotechnology: Tissue culture in crop improvement, Micropropagation. Meristem culture and production of virus-free plants. Haploids in plant breeding; Anther and microspore culture. Embryo and ovary culture. Somatic hybridization; Protoplast isolation and fusion, cybrids. Somaclonal variation. Synthetic seeds. Cryopreservation, Elicitation with various biotic and abiotic elicitors.

UNIT – III **9 Hrs**

Biotechnology for Sustainable Agriculture: An overview, Biotechnological tools to enhance sustainable production, Sustainable agriculture and food security, Green food production, Green house technology and protected cultivation: Types of Green house, Various component of green house, Design, criteria and calculation. Green house irrigation system, Pytotrons: Hydroponics and aeroponics. Organic Farming: Concept of Integrated nutrient management and Integrated pest management, molecular farming in animals and plants. Nanotechnology and its implication in Agricultural Biotechnology.

UNIT - IV **9 Hrs**

Introduction and basic concepts of classical plant breeding: The status of plant breeding in agriculture, the importance of breeding, history and development of plant breeding. Conventional techniques, methods and practices of breeding: The techniques and selection methods. Breeding methods for self, cross-pollinated and vegetatively propagated. Peculiarities of the biennial and perennial species. Nature of heterosis, heterosis theory explaining, using heterózního effect in plant-breeding techniques for the breeding of F1 hybrids. Male sterility, genetic determination of male sterility, the use of male sterility in breeding F1 hybrids. Molecular markers and genome editing in agricultural crops.

UNIT – V **9 Hrs**

Alternative breeding techniques: Mutation breeding, induced mutagenesis, mutagens used, methods of working. Remote hybridization causes problems with pollination of species and the possibility of overcoming the properties of distant hybrids. Properties of polyploids, the use of polyploidy in plant breeding, methods of obtaining polyploid breeding, use of aneuploidy. Haploids in plant breeding. Breeding for resistance to pests and diseases, genetic nature of resistance.

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Remember and explain various fundamentals of Agricultural Biotechnology with reference to breeding techniques and regulatory frameworks
CO2	:	Apply the knowledge of modern tools to analyze the improvement of agricultural practices
CO3	:	Analyze and apply various breeding techniques for crop improvement
CO4	:	The ability to propose an approach for the desired properties of the plants with the classical and biotechnological methods.

Reference Books

1. S S Purohit, Agricultural Biotechnology, 3rd ed., Agribios Publications, 2010, ISBN-13 : 978-8177543551
2. Stuart J. Smyth, Peter W.B. Phillips and David Castle, Handbook on Agriculture, Biotechnology and Development, 1st ed, Edward Elgar Publications, 2015, ISBN: 978178347 1355.

3. Bos I & Caligari P, Selection Methods in Plant Breeding, 2nd ed., Chapman & Hall, 2007, ISBN-13: 978-1402063695
4. Vijay Rani Rajpal, S. Rama Rao, S.N. Raina, Molecular Breeding for Sustainable Crop Improvement, Vol.2., 1st edition, Springer International Publishing, 2016, ISBN-13: 978-3319270883

Scheme of Continuous Internal Evaluation (CIE): 20 + 40 + 40 = 100

QUIZZES: Quizzes will be conducted in online/offline mode. Two quizzes will be conducted & Each Quiz will be evaluated for 10 Marks. The sum of two quizzes will be the Final Quiz marks.

TESTS: Students will be evaluated in test, descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). Two tests will be conducted. Each test will be evaluated for 50 Marks, adding upto 100 Marks. Final test marks will be reduced to 40 Marks.

EXPERIENTIAL LEARNING: Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning and Program specific requirements (15), Video based seminar/presentation/demonstration (25) adding upto 40 marks.

Scheme of Semester End Examination (SEE) for 100 marks: The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MBT323B3	**INTEGRATED BIOLOGICAL SYSTEMS**	CIE Marks	:	100
Credits L-T-P	:	3- 1- 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-B)*	SEE Durations	:	3 Hrs

UNIT – I **9 Hrs**

Introduction to Systems Biology and Drug Discovery: Systems Biology: Scope, applications in medicine, cancer, and drug discovery. Concepts, implementation, and applications. Databases: BioFnet, Biomodels, Biosystems, InnateDB, Panther. Computer-Assisted Drug Discovery: Overview of the drug discovery process, compound searching, target identification, target characterization, and molecular interactions. Introduction to structure-based and ligand-based drug design.

UNIT – II **9 Hrs**

Modeling and Computational Tools: Modeling Tools- SBML, CellML, MathML, Petri Nets. Reconstruction of metabolic networks using genome information. Structure Generation and Visualization: Homology modeling, model evaluation, energy minimization, and bioactive conformations. Data Analysis Techniques: High-throughput data analysis methods including clustering, searching algorithms, and support vector machines.

UNIT – III **9 Hrs**

Network Models and Drug Design: Network Models: Metabolic control analysis, glycolysis, signal transduction pathways (Jak-Stat, MAP kinase), and gene expression modeling. Molecular Mechanics and Docking: Force fields for drug design, docking algorithms, scoring functions, and pharmacophore models. Case studies on protein-ligand interactions and compound refinement.

UNIT – IV **9 Hrs**

Simulation and Dynamic Modelling: Molecular Dynamics Simulations, Concepts of thermodynamics, force fields, integrators, thermostats. Sampling techniques for different ensembles. Applications in Systems Biology: Modeling of circadian rhythms, gene regulatory networks, and emerging phenotypes using deterministic models. MMGBSA and Free Energy Calculations: Principles and applications in evaluating drug-target interactions.

UNIT – V **9 Hrs**

Advanced Concepts and Optimization: Multiscale Representations- Gene regulatory networks, Boolean functions, and cytomics. Spatio-temporal systems biology. Optimization in Drug Design: QSAR (2D and 3D-QSAR), ADMET studies, and toxicity assessment. Emerging Techniques: Global gene expression assays (Microarrays, RNA-seq), protein design, and mapping genotype-phenotype relationships in cellular networks. Case Studies and Applications- Integrating multiomics data for drug discovery and personalized medicine.

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Understand the principles and applications of systems biology and in silico drug discovery.
CO2	:	Utilize SBML, CellML, docking methods, and pharmacophore modeling for designing drugs and studying biological networks.
CO3	:	Evaluate experimental and simulation data for genomics, proteomics, and drug discovery.
CO4	:	Develop models for systems biology processes, such as gene regulatory networks, and execute drug discovery protocols.

Reference Books

1. Andres Kriete, Roland Eils, Computational Systems Biology, 2nd edition, Academic Press, 2013, ISBN:9780124059269
2. Andrzej K. Konopka, Systems Biology: Principles, Methods and Concepts, 1st edition, CRC Press, 2006, ISBN-13: 978-0824725204

3. Gustavo Caetano-Anollés, Evolutionary Genomics and Systems Biology, 1st edition, John Wiley & Sons, 2010. ISBN-13: 9781118210710
4. Huma M. Lodhi, Stephen H. Muggleton, Elements of Computational Systems Biology, 1st edition, John Wiley & Sons, 2010, ISBN-13: 9780470556740

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MBT324B4	**FORENSIC SCIENCE**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-B)*	SEE Durations	:	3 Hrs

UNIT - I — **9 Hrs**

Introduction: Introduction to Forensics, Definition and scopes of forensics, History and chronology of the events in forensics, and important milestones in the forensics, importance and significance of court in forensics; procedure and protocol: Inquest and medical examiners systems, powers of courts, documentary evidences and witness, (Doctors guide to court), application of the forensics: Forensic anthropology, Forensic entomology, Forensic psychiatry, Forensic odontology. Forensic pathology: Rigor mortis, livor mortis, algor mortis.

UNIT - II — **9 Hrs**

Crime Lab and Crime Scene Analysis: Organization of crime lab at various levels in India (Center and State), facilities offered by various laboratories. Services of the crime lab, basic services of the crime lab, optional services. **Dactyloscopy**- Definition, various events and its significance, fingerprints its classification and patterns (concept of LAW).

Crime scene- Identification (Race, Sex, Age), methodical search for evidence. Analysis of the physical evidences- definition, importance and source of evidence, type, expert unit men, and sealing of physical evidence

UNIT - III — **9 Hrs**

Crime Scene Evidence: Classification of crime scene evidence – physical and trace evidence. Locard principle. Collection Handling, labeling, sealing of evidence. Hazardous evidence. Preservation of evidence. Chain of custody. Reconstruction of crime scene.

Physical Evidence: Glass evidence – collection, packaging, analysis. Paint evidence – collection, packaging and preservation. Fiber evidence – artificial and man-made fibers. Collection of fiber evidence. Identification and comparison of fibres. Soil evidence – importance, location, collection and comparison of soil samples. Cyber forensics: Fundamentals and application

UNIT - IV — **9 Hrs**

Crime Scene Management: Types of crime scenes – indoor and outdoor. Securing and isolating the crime scene. Crime scene search methods. Safety measures at crime scenes. Legal considerations at crime scenes. Documentation of crime scenes – photography, videography, sketching and recording notes. Duties of first responders at crime scenes. Coordination between police personnel and forensic scientists at crime scenes. The evaluation of 5Ws and 1H. Toolmark evidence. Classification of tool marks. Collection, preservation and matching of tool marks. Restoration of erased serial numbers and engraved marks.Forensic gemmology. FRYE standard and DAUBERT criteria.

UNIT - V — **9 Hrs**

Toxicology and ethics in Forensic Science: Forensic toxicology, General Materials, Custodial Deaths, General Toxicology, Corrosive Poisons, Vegetable Alkaloid Poisons, Irritant Poisons, Non–Metallic & Metallic poisons, Inebriant Poisons Irrespirable Gases, Drug & Insecticides, Food Poisoning. Science and professional ethics: significance and limitations, code of conduct and code of ethics for forensics and their application, ethical requirements, ethical dilemmas and their resolutions.

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Recognize the scientific, ethical and legal implications in the collection, storage and dispatch of forensic evidence.
CO2	:	Comprehend the role of forensic scientist in the collection and interpretation of evidence and the presentation of expert testimony, and its importance to assurance of judicial equity
CO3	:	Evaluate the crime lab and their functionality along with its management.
CO4	:	Analyse the forensics in cyber for retention of security and impact of toxicology in forensics to submissive in ethics and moral values

Reference Books
1. Criminalistics: An Introduction to Forensic Science; R Saferstein; 2007, Prentice Hall; 9st ed;. ISBN: 0-13-221655- 8
2. Forensic Science in Crime Investigation, B.S.Nabar; 2002 Asia Law House; 3rd edition;;ISBN: 81861969944
3. Forensic science : from the crime scene to the crime lab, Saferstein, Richard, 2009, Prentice Hall; 2nd ed., ISBN 0- 13-139187-9 (978-0-13-139187-1)
4. The essentials of Forensic Medicine and Toxicology; K.S.Narayana Reddy; 2004;Chand & Sons, 23rd edition; ISBN: 8139427131

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**
RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MBT324C1	**BIOPRINTING AND MOLECULAR COMMUNICATIONS**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-C)*	SEE Durations	:	3 Hrs

UNIT - I	**09 Hrs**
Bioinks: Biomaterials used for bioink development with their merits and demerits. Inkjet Bioprinting; Polymers for Bioprinting; Alginate Bioinks, Hydrogels for 3D Bioprinting Applications; Bioprinting of Organoids; 3D Printing and Nano manufacturing; Regenerative medicines; Bioprinting Using Aqueous Two-Phase System; Critical parameters of bioink formulations for bioprinting, modulation of bioink properties to control different processing conditions. Development of a Smart Bioink for Bioprinting Applications.	
UNIT - II	**09 Hrs**
Bioprinting: Bioprinting Essentials of Cell and Protein Viability; Software for Biofabrication; Design and Quality Control for Translating 3D-Printed Scaffolds; different types of bioprinting techniques and their advantages and disadvantages. 3D tissue designing and 3D tissue/organ printing; various process parameters and their role in bioprinting.	
UNIT - III	**09 Hrs**
Bioprinted research 3D models and techniques: Biomaterials for In-vitro, In-vivo, and ex-vivo manipulation of cells, Bioprinter to engineer tissues for regenerative medicines/in vitro tissue/organ models. Indirect Rapid Prototyping for Tissue Engineering. Current Developments in Tissue and Organ Regeneration, Cross-linking Hydrogel Systems.	
UNIT - IV	**09 Hrs**
In situ bioprinting and 4D bioprinting: Stereolithographic 3D Bioprinting for Biomedical Applications; Extrusion. Bioprinting Biofabrication-based strategies from bench-to-bed to address specific clinical problems. Tissue-Specific Bioink from Xenogeneic Sources for 3D Bioprinting of Tissue Constructs, 3D Printed Bio scaffolds for Developing Tissue-Engineered Constructs, Bio-Inspired Hydrogels via 3D Bioprinting, 3D Printing for Tissue Regeneration. Challenges, and future direction of bioprinting in skin, Nerve and cardiac tissues.	
UNIT - V	**09 Hrs**
Molecular communications: Traditional and advanced types, Communication carriers, signal types, Propagation speed, communication environment, Phenomena and Chemical Status, Information and chemical reactions at receiver point, Stochastic communication and low energy consumption. Molecular Communication systems. Molecular computing.	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Understand the basic principles and of various types of 3D Bioprinting and their development
CO2	:	Evaluate the manfacturing, quality control and associated regulatory requiremnts of 3D bioprinting products.
CO3	:	Apply knowledge and understanding towards growth, interactions and related mechanism with various human populations based on experimental design
CO4	:	Describe approved 3D Bioprinting products and development issues

Reference Books

1. Anthony Atala and James J. Yoo, Essentials of 3D Biofabrication and Translation. 1st edition, Elsevier, 2015, ISBN-13: 978-0128009727.
2. Lijie Grace Zhang, John P. Fisher and Kam W. Leong, 3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine, 1st edition, Elsevier, 2015, ISBN13: 9780128005477.
3. Gabor Forgacs, Wei Sun, Biofabrication - Micro- and Nano-fabrication, Printing, Patterning and Assemblies, 1st Edition, Elsevier, 2013, ISBN-13 : 978-1455728527
4. Tadashi Nakane, Andrew W Eckford, Molecular communication, Cambridge university press, 2024, ISBN – 9781108832762

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MBT324C2	**CLINICAL IMMUNOLOGY**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-C)*	SEE Durations	:	3 Hrs

UNIT - I	**9 Hrs**
Introduction to Immune System: organs, cells and molecules involved in innate and adaptive immunity. Hematopoiesis and its regulation, role of cytokines, chemokines and leukotrienes, phagocytosis and microbicidal mechanisms. Immediate hypersensitivity: role of eosinophils, and mast cells. ; Immune modulators.	
UNIT - II	**9 Hrs**
Receptors of innate immunity: Toll-like receptors, opsonization, Immunochemistry of Antigens - Immunogenicity, Antigenicity, haptens, super antigens, Toxins-Toxiods, Hapten carrier system. B and T cell epitopes, T cell receptors, Activation of T cells, APC-T cell interaction, Differentiation and activation of B cells, BCR and its editing, Major Histocompatibility Complex: genetic organization of H2 and HLA complexes. Class I and class II MHC molecules, MHC restriction. Antigen processing and presentation pathways.	
UNIT - III	**9 Hrs**
Antibody structure and function: Classification of immunoglobulins, immunoglobulin domains, concept of variability, isotypes, allotypes and idiotypic markers. Antigen-antibody interactions, Immunoglobulin genes, VJ/VDJ rearrangements and genetic mechanisms responsible for antibody diversity,Class switching, The complement system: classical and alternative pathways.	
UNIT - IV	**9 Hrs**
Advances in Immunotechnology: Hybridoma, monoclonal antibodies, and antibody engineering, Immunological Techniques antibody generation, detection of molecules using ELISA, RIA, Western blot, immunoprecipitation, flow cytometry, immunofluorescence microscopy, In situ localization techniques such as FISH, GISH, Monoclonal antibodies and their application, CART – cell therapy.	
UNIT - V	**9 Hrs**
Application of immunological principles: Transplantation immunology- immunological basis of graft rejection and its clinical manifestations, immunosuppressive therapy, Immunostimulants, Vaccines: types, recombinant vaccines and clinical applications, Tumor immunology and autoimmunity.	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Comprehend the concepts of immunity and immune reactions along with its various components.
CO2	:	Analyse the various types of immune responses and reaction for being a better well being
CO3	:	Apply the knowledge of immunology to identify various immunological reactions and interactions to counter the various biological health threatens
CO4	:	Evaluate the significance and applications of various advance immunological tools, techniques and mechanisms.

Reference Books

1. Ashim K. Chakravarthy. Immunology and Immunotechnology, 1st edition, Oxford University Press. 2006. ISBN-9780195676884
2. T. Kindt, R. Goldsby, B. A. Osborne, Kuby Immunology, 6th edition, W. H. Freeman Publishers, 2006. ISBN-13:978-0716767640
3. Sudha Gangal and Shubhangi Sontakke "Textbook of basic and clinical Immunology" Universities Press. 2013. ISBN-9788173718298
4. Ajoy Paul, “Textbook of Immunology” Books and Allied (P) Ltd. 2016. ISBN- 978-93-84294-72-4

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MBT324C3	**DESIGN OF BIOREACTORS**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-C)*	SEE Durations	:	3 Hrs

UNIT - I	**9 Hrs**
Process Design of Heat Exchanger: Heat Exchanger, Types of Heat exchanger. Process Design of Double pipe heat exchanger (Inner diameter and outer diameter of inner and outer pipes, Heat transfer inside and outside heat transfer co-efficient) Process Design shell and tube heat exchanger ((Inner diameter and outer diameter of tubes, Shell inner diameter, inside and outside Heat transfer inside, and outside heat transfer co-efficient).	
UNIT - II	**9 Hrs**
Process Design of Condenser: Types of condensers, process design of horizontal (Heat load, coolent temperature, Tube size, shell size, number of tubes). Process design of vertical condensers ((Heat load, coolent temperature, Tube size, shell size, number of tubes).	
UNIT - III	**9 Hrs**
Process Design of evaporator: Introduction, types of evaporators, methods of feeding of evaporators, general design consideration of Single Effect evaporator (Throughput, solution viscosity, fouling and foaming properties).	
UNIT - IV	**9 Hrs**
Process design of distillation column: Introduction to distillation column, Types of distillation column, Design of bubble cap distillation column (Plate contactors, plate spacing, column diameter).	
UNIT – V	**9 Hrs**
Process design of absorption column: Introduction to absorption column, Design of packed bed absorption column (Throughput volume, break point, exhaust point, bed height, mass transfer co-efficient).	

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Understand and remember the design procedure for various bioprocess equipments.
CO2	:	Apply Engineering principles to design bioprocess equipments
CO3	:	Calculate the physical dimensions of various parts of bioprocess equipments and accessories
CO4	:	Analyze various design options at all design stages

Reference Books

5. Chemical Engineers Handbook, R.H.Perry and D.W.Green, 7th Edition, 1998, McGraw Hill, ISBN: 0-07-115982-7.
6. Chemical Engineering, J.M.Coulson and J.F.Richardson, Vol.6, 3rd Edition 1993, Pregman Press, ISBN: 0750641428.
7. Process Equipment Design, Brownell and Young, 1st Edition, 1959, Wiley publications, ISBN: 0471113190.
8. Process Equipment Design, M.V.Joshi, 3rd Edition, Reprint 1998, Macmillan and Co. India, Delhi, ISBN 023-063-8104

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MBT324C4	**ADVANCES IN GENOMIC SEQUENCING**	CIE Marks	:	100
Credits L-T-P	:	3- 1 - 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core Courses (Cluster Electives) (Group-C)*	SEE Durations	:	3 Hrs

UNIT – I	**9 Hrs**

Advanced Sequencing Technology: Overview of Sequencing Platforms: Deep dive into the latest sequencing platforms (e.g., Illumina, PacBio, Oxford Nanopore), sequencing chemistries, and innovations in sequencing technologies. Comparative Analysis of Sequencing Platforms: Advantages, limitations, and need for hybrid sequencing approaches to enhance read accuracy and coverage. Base Calling and Quality Assessment: Advanced algorithms for base calling, interpretation of Phred quality scores, and quality control metrics. Preprocessing of Sequencing Data: Handling adapter and primer contamination, advanced adapter trimming techniques, removal of low-quality reads using various clipping tools, and assessing the impact of preprocessing on downstream analysis.

UNIT – II	**9 Hrs**

High-Throughput Data Analysis Techniques: NGS Data Retrieval and Format Handling: File formats (FASTQ, BAM, SAM, VCF), conversion tools, and best practices for data management. Alignment and Assembly: Optimization of alignment algorithms (e.g., Burrows-Wheeler Aligner, Bowtie2), index building, handling large reference genomes, and strategies for de novo assembly. Variant Calling and Annotation: Advanced pipelines for SNPs, Indels, and structural variant detection. Gene-Level Statistical Analyses: Differential gene expression analysis using RNA-seq data, statistical models, and visualization. Artifact Identification: Addressing common alignment artifacts and bias in NGS data, including duplicates, mapping bias, and base composition biases.

UNIT – III	**9 Hrs**

Big Data Analytics and High-Performance Computing (HPC): Cloud Computing in NGS: Introduction to cloud-based platforms (e.g., AWS, Google Cloud, Azure) for large-scale NGS data storage and analysis. Hadoop Architecture and Bioinformatics: MIKE2.0, distributed parallel processing, MapReduce concepts applied to NGS data analysis. HPC in NGS: Overview of HPC clusters, job scheduling systems (e.g., SLURM), and scripting for batch processing. Linux for Bioinformatics: Advanced Linux commands and scripting for automation of NGS workflows, managing parallel jobs, and custom tool integration. Data Security and Compliance:

UNIT – IV	**9 Hrs**

Advanced Workflows for NGS Data Analysis: Genome and Exome Sequencing: Advanced pipelines for whole genome and exome sequencing, optimization of analysis for variant-rich regions. Transcriptomics and Epigenomics: Analysis of RNA-seq, small RNA-seq, and methylome sequencing, including quantification and differential analysis of expression data. ChIP-seq and ATAC-seq Analysis: Tools and techniques for analyzing chromatin accessibility and transcription factor binding sites. Metagenomics and Microbiome Analysis: Tools and workflows for 16S rRNA and whole metagenome shotgun sequencing; community profiling and functional annotation. Emerging NGS Tools: Introduction to new tools, technologies, and methods like single-cell RNA sequencing, spatial transcriptomics, and their applications.

UNIT – V	**9 Hrs**

Applications of NGS in Research and Clinical Settings: NGS in Complex Disease Research: Applications in genome-wide association studies (GWAS) for complex diseases, including cancer and neurodegenerative disorders. Clinical Sequencing and Diagnostics: Implementation of NGS in personalized medicine, including applications in oncology, rare disease diagnosis, and pharmacogenomics. NGS in Agriculture: Applications in crop improvement, trait discovery, and genotyping-by-sequencing (GBS) for plant breeding. NGS in Drug Development: Role of NGS in target identification, biomarker discovery, and patient stratification in clinical trials. Future Directions in NGS: Trends like long-read sequencing, single-cell multiomics, and their potential to transform precision medicine and environmental studies.

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Understand the basic knowledge of Next Generation Sequencing
CO2	:	Analyze and apply the appropriate tools and techniques to perform high throughput data analysis
CO3	:	Design pipeline for various applications of NGS analysis
CO4	:	Develop high throughput data analysis tools for various biological applications

Reference Books

1. Stuart M. Brown, Next-generation DNA sequencing informatics, 2nd edition, Cold Spring Harbor Laboratory, Press, 2015, ISBN-13 : 978-1621821236
2. Naiara Rodríguez-Ezpeleta, Michael Hackenberg, Ana M. Aransay, Bioinformatics for High Throughput Sequencing, 1st edition, Springer, 2011, ISBN: 978-1-4614-0781-2
3. Kulski, J. Next Generation Sequencing - Advances, Applications and Challenges,1st editon, Intech, 2017, ISBN13: 978-953-51-2240-1
4. Urszula Demkow and RafalPloski, Clinical Applications for Next-Generation Sequencing, 1st edition, Academic Press, 2015, ISBN-13 : 978-0128017395

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**

Sl.No.	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)

Q.NO.	CONTENTS	MARKS
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MBT325DA	**NATURE IMPELLED ENGINEERING**	CIE Marks	:	100
Credits L-T-P	:	3-0-0		SEE Marks	:	100
Hours	:	45L+45EL	*Interdisciplinary Courses (Global Electives) (Group-D)*	SEE Durations	:	3 Hr

UNIT – I	**9 Hrs**
Bio-Inspired designs-biomimetics: Termites; Sustainable buildings, Insect foot adaptations for adhesion. Bees and Honeycomb Structure. Namib Desert Beetle; Harvesting desert fog- Nature's water filter. Biopolymers, Bio-steel, Bio-composites, multi-functional biological materials. Antireflection and photo-thermal biomaterials, Invasive and non-invasive thermal detection inspired by skin.	
UNIT – II	**9 Hrs**
Plant inspired Technologies: Photosynthesis and Photovoltaic cells, Bionic/Artificial leaf. Lotus leaf effect for super hydrophobic surfaces. Flectofin®, a new façade-shading system inspired by flower of the Bird-of-Paradise (Strelitzia reginae). Robotic Solutions Inspired by Plant Root.	
UNIT – III	**9 Hrs**
Bio-Inspired technologies for medical applications: Organ system- Circulatory- artificial blood, artificial heart, pacemaker. Respiratory- artificial lungs. Excretory- Artificial kidney and skin. Artificial Support and replacement of human organs: artificial liver and pancreas. Total joint replacements- artificial limbs. Visual prosthesis -artificial / bionic eye.	
UNIT – IV	**9 Hrs**
Bio-Inspired driven technologies for industrial applications: Biosensors: Artificial tongue and nose. Biomimetic echolation. Insect foot adaptations for adhesion. Thermal insulation and storage materials. Bio-robotics.	
UNIT – V	**9 Hrs**
Bio-inspired computing: Cellular automata, neural networks, evolutionary computing, swarm intelligence, artificial life, and complex networks. Genetic Algorithms, Artificial Neural Networks. Artificial intelligence and MEMS.	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Contemplate a deep understanding of biological systems, mimetics structures, and functions that inspire engineering innovations for adaptability and sustainability.
CO2	:	Endeavor biological principles from nature driven techniques to design engineering systems for solving real-world challenges
CO3	:	Appraise the bioinspired materials for their advanced applications in the domain of health, energy and environmental sustainability.
CO4	:	Paraphrase biomimicry and ethics in bioinspired engineering designs, ensuring that their solutions are environmentally responsible and socially conscious

Reference Books:

1. Yoseph Bar-Cohen. Biomimetics: Biologically Inspired Technologies D. Floreano and C. Mattiussi, "Bio-Inspired Artificial Intelligence", CRC Press, 2018. ISBN: 1420037714, 9781420037715.
2. Guang Yang, Lin Xiao, and Lallepak Lamboni. Bioinspired Materials Science and Engineering. John Wiley, 2018. ISBN: 978-1-119-390336.
3. M.A. Meyers and P.Y. Chen. Biological Materials, Bioinspired Materials, and Biomaterials Cambridge University Press, 2014 ISBN 978-1-107-01045.
4. Tao Deng. Bioinspired Engineering of Thermal Materials. Wiley-VCH Press, 2018. ISBN: 978-3-527-33834-4.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II							
Course Code	:	MBT325DB	**CLINICAL DATA MANAGEMENT**	CIE Marks	:	100	
Credits L-T-P	:	3-0-0		SEE Marks	:	100	
Hours	:	45L+45EL	*Interdisciplinary Courses (Global Electives) (Group-D)*	SEE Durations	:	3 Hrs	

UNIT – I	**9 Hrs**
Fundamentals of Healthcare Data and Analytics: Overview, importance, and evolution of health informatics in the digital age, Healthcare Data Types: Structured vs. unstructured data, clinical vs. operational data, and sources of healthcare data, Data Conversion and Integration: Data standardization, integration into clinical data warehouses, and data cleaning. Data Analytics: Introduction to descriptive, predictive, and prescriptive analytics in healthcare. Use of AI and machine learning for improved outcomes, Challenges and Future Trends: Data privacy, interoperability issues, the role of informatics in personalized medicine, and the future of digital health.	
UNIT – II	**9 Hrs**
Electronic Health Records (EHRs) and Digital Health: Overview of EHRs: Key components, data capture mechanisms, and the shift towards integrated EHR systems. Scope and Adoption: Role of EHRs in enhancing patient care, interoperability, and data sharing between healthcare providers. Implementation Process: Steps for selecting, deploying, and optimizing EHR systems, including vendor selection and compliance with healthcare regulations. Challenges in EHRs: Usability issues, data quality, resistance to adoption, and strategies for overcoming these barriers. Digital Health Innovations: Impact of telemedicine, remote patient monitoring, and digital therapeutics on EHR integration.	
UNIT – III	**9 Hrs**
Data Standards, Interoperability, and Medical Coding: Introduction to Standards: Need for data standards in health informatics, and their role in ensuring interoperability. Terminology and Content Standards: Deep dive into ICD, SNOMED CT, LOINC, and HL7 FHIR. Data Exchange and Transport Standards: HL7, DICOM, CDA, and emerging standards for seamless data exchange. Medical Coding Systems: Role of medical coding in billing, clinical documentation, and outcome measurement. Overview of CPT, ICD-10, and DRG codes. Emerging Trends: Role of AI in medical coding and billing, and the shift towards real-time data standardization.	
UNIT – IV	**9 Hrs**
Health Informatics Ecosystem: Introduction to the ecosystem, including hospitals, clinics, insurance providers, and regulatory bodies. Key Players and Stakeholders: Role of informatics professionals, data scientists, clinicians, and IT staff in healthcare. Challenges and Barriers: Addressing technical, organizational, and regulatory challenges in health informatics. Career Opportunities: Overview of roles like clinical informatics specialist, health data analyst, and telehealth coordinator. Resources and Professional Development: Important certifications, online resources, and organizations (e.g., HIMSS, AMIA).	
UNIT – V	**9 Hrs**
Health Information Privacy, Security, and Ethics: Introduction to Privacy and Security: Core principles of data privacy, HIPAA, and GDPR in healthcare. Security Principles: Confidentiality, integrity, availability, encryption methods, and access control mechanisms. Authentication and Identity Management: Role of biometric authentication, two-factor authentication, and secure access protocols. Data Security in the Cloud: Cloud computing in healthcare, managing risks in cloud-based data storage, and hybrid cloud models. Ethics in the use of AI in healthcare, managing bias in algorithms, and ensuring equitable access to digital health technologies.	
Course Outcomes: After going through this course the student will be able to:	

CO1	:	Understand the key principles and challenges of health informatics, and apply them to real-world scenarios.	
CO2	:	Effectively manage the process of data capture, conversion, and analysis to generate actionable insights.	
CO3	:	Apply knowledge of medical coding, data standards, and interoperability to improve data sharing and clinical workflows.	

CO4	:	Implement robust security measures to protect patient data, and navigate ethical issues in health informatics.	

Reference Books:

1. Robert E. Hoyt Ann K. Yoshihashi, Health Informatics, Practical guide for Healthcare and Information Technology Professionals, 6th edition, Informatics Education, 2014, ISBN: 978-0-9887529-2-4
2. Kathryn J. Hannah Marion J. Ball, Health Informatics, Springer Series edition, Springer, 2005, ISBN: 1- 85233-826-1
3. William R Hersh, Health Informatics, A Practical guide, 8th edition. 2022, ISBN 978-1-387-85475-2
4. Pentti Nieminen. Medical informatics and data analysis 1st edition, MDPI AG, 2021, ISBN-13 : 978- 3036500980

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component
[20 (Q) + 40 (T) + 40 (EL) = 100 marks)

Sl.No.	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)

Q.NO.	CONTENTS	MARKS
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	**:**	**MCN325DC**	**CYBER FORENSICS AND CYBER LAWS**	**CIE Marks**	**:**	**100**
Credits L-T-P	**:**	**3-0-0**	***(Theory)***	**SEE Marks**	**:**	**100**
Hours	**:**	**45L+45EL**	***(Interdisciplinary Basket Course-D)***	**SEE Duration**	**:**	**3 Hours**

UNIT – I — **9 Hours**

Computer Forensics in Today's World

Introduction to Computer Forensics and Digital Evidence, the Role of the Forensic Investigator, Understanding Forensic Readiness. Legal Issues and Considerations, Types of Computer Forensic Investigations, Forensic Investigation Process.

UNIT – II — **9 Hours**

Investigation Process

Computer Forensics Investigation Methodology, Handling Digital Evidence, Chain of Custody and Documentation, Evidence Preservation: Hashing and Imaging, Investigation Planning and Legal Approval, Searching and Seizing Computers: Search and Seizure Procedures, Obtaining a Search Warrant, Securing the Crime Scene

UNIT – III — **8 Hours**

Digital Evidence

Types of Digital Evidence (Physical, Logical, Latent), Collecting and Preserving Digital Evidence, Writing Reports on Digital Evidence, Identifying Evidence Sources: Hard Drives, Network Logs, Databases, Evidence Recovery Techniques, First Responder Procedures: First Responder Role in Digital Investigations, Protecting and Securing Evidence, Best Practices for Incident Response

UNIT – IV — **8 Hours**

Jurisdiction of Cyberspace:

Information Technology Law Literature and Glossary, Information Technology Law Concepts, Jurisdictional Issues in Cyber Space, scope of I.T. laws,

Law and the Internet:

Domain issues in Internet, Regulatory body, ICANN regulations

UNIT – V — **8 Hours**

Security Governance Objectives –

Security Architecture, Risk Management Objective, Developing A Security Strategy, Sample Strategy Development.

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Gain a comprehensive understanding of Cyberfornsic and Investigation
CO2	:	Apply cyber forensics measures, tools, and techniques to protect systems, networks, and information.
CO3	:	Analyse the Legal Frameworks governing the internet
CO4	:	Exploration of Security Frameworks in the Cyber space.

Reference Books

1. EC-Council CHFI Course Outline: https://www.eccouncil.org/programs/computer-hacking-forensic-investigator-chfi/
2. Guide to Computer Forensics and Investigations" by Bill Nelson, Amelia Phillips, and Christopher Steuart, 6th Edition (latest), Cengage Learning, February 15, 2018, 978-1337568944
3. The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics" by John Sammons, Edition: 2nd Edition (latest) Syngress (an imprint of Elsevier), June 30, 2014, ISBN-10: 0128016353

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**

Sl.No.	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)

Q.NO.	CONTENTS	MARKS
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	**:**	**MCV325DD**	**INDUSTRIAL SAFETY AND HEALTH**	**CIE Marks**	**:**	**100**
Credits L-T-P	**:**	**3-0-0**	*(Theory)*	**SEE Marks**	**:**	**100**
Hours	**:**	**42L**	*Interdisciplinary basket course -D*	**SEE Duration**	**:**	**3 Hours**

UNIT – I — **9 Hours**

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure. National Policy and Legislations on EHS in India - Regulations and Codes of Practice - Role of trade union safety representatives. Occupational health and safety:
Introduction: Health, Occupational health: definition, Interaction between work and health, Health hazards, workplace, economy and sustainable development. Development of accident prevention programs and development of safety organizations.

UNIT – II — **9 Hours**

Work as a factor in health promotion. Potential health hazards: Air contaminants, Chemical hazards, Biological hazards, Physical hazards, Ergonomic hazards, Psychosocial factors, Evaluation of health hazards: Exposure measurement techniques, Interpretation of findings, recommended exposure limits. Controlling hazards: Engineering controls, Work practice controls, Administrative controls. Occupational diseases: Definition, Characteristics of occupational diseases, Prevention of occupational diseases.

UNIT – III — **8 Hours**

Hazardous Materials characteristics and effects on health: Introduction, Chemical Agents, Organic Liquids, Gases, Metals and Metallic Compounds, Particulates and Fibers, Alkalies and Oxidizers, General Manufacturing Materials, Chemical Substitutes, Allergens, Carcinogens, Mutagens, Reproductive Hazards, Sensitizers and Teratogens, Recommended Chemical Exposure Limits. Physical Agents, Noise and Vibration, Temperature and Pressure, Carcinogenicity, Mutagenicity and Teratogenicity. Ergonomic Stresses: Stress-Related Health Incidents, Eyestrain, Repetitive Motion, Lower Back Pain, Video Display Terminals.

UNIT – IV — **8 Hours**

Occupational safety and Health act. Occupational Safety and Health Administration, right to know Laws, Accident Causation, Correcting Missing Skills, Investigator Tendencies and Characteristics, Theories of accident causation: Domino theory, Human Factors theory, Accident/Incident theory, Epidemiological theory and systems theory of accident causation.GD

UNIT - V — **8 Hours**

Environmental Health and Safety Management: Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and implementation and review – ISO 45001-Strucure and Clauses-Case Studies.
Occupational Health and Safety Considerations: Water and wastewater treatment plants, Construction material manufacturing industries like cement plants, RMC Plants, precast plants and construction sites, Municipal solid waste management.

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Explain the Industrial and Occupational health and safety and its importance.
CO2	:	Demonstrate the exposure of different materials, occupational environment to which the employee can expose in the industries.
CO3	:	Exposure to the onset of regulatory acts and accident causation models.
CO4	:	Demonstrate the significance of safety policy, models and safety management practices.

Reference Books
1. Industrial Health and Safety Acts and Amendments, by Ministry of Labor and Employment, Government of India.
2. Fundamentals of Industrial Safety and Health by Dr.K.U.Mistry, Siddharth Prakashan, 2012.
3. Goetsch, D. L. (2011). Occupational Safety and Health for Technologists, Engineers and Managers 3rd edition. Prentice hall.
4. David. A. Calling - Industrial Safety Management and Technology, Prentice Hall, New Delhi.
5. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995.
6. ISO 45001:2018 Occupational health and safety management systems – Requirements with guidance for use, International Organisation for Standardisation, 2018.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MCV325DE	**ADVANCED TECHNOLOGIES FOR TRANSPORTATION SYSTEMS**	CIE Marks	:	100
Credits L-T-P	:	3-0-0	*(Theory)*	SEE Marks	:	100
Hours	:	42L	*(Interdisciplinary Basket Course-D)*	SEE Duration	:	3 Hours

UNIT - I	**8 Hours**

Introduction to Intelligent Transportation Systems (ITS): Definition, objectives, Historical Background, Benefits of ITS –ITS. ITS User Services. ITS Applications. Strategic Needs Assessment and Deployment. Regional ITS Architecture Development Process. ITS Standards. ITS Evaluation. ITS Challenges and Opportunities.

UNIT - II	**8 Hours**

Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.

Telecommunications in ITS: Information Management, Traffic Management Centres (TMC). Application of sensors to Traffic management; Traffic flow sensor technologies; Transponders and Communication systems; Data fusion at traffic management centres; Sensor plan and specification requirements; Elements of Vehicle Location and Route Navigation and Guidance concepts.

UNIT - III	**9 Hours**

Traffic Engineering - Fundamental relations of traffic flow, Traffic Stream models - , Shock wave, Car following models, Lane changing models, Vehicle arrival models, PCU values, Interrupted and Uninterrupted flow. Signalized intersection design and Analysis based on IRC, HCM and Indo –HCM. Numerical Problems. Traffic Simulation. Numerical Problems. Application of IOT, Machine learning in traffic management.

UNIT - IV	**9 Hours**

Transportation Network Analysis – Basic Introduction to Travel demand modelling, Trip generation, Distribution, Modal Split and Trip Assignment. Transit Capacity, ITS functional areas: Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS)

UNIT - V	**8 Hours**

ITS applications: Traffic and incident management systems; ITS and sustainable mobility, travel demand management, electronic toll collection, ITS and road-pricing. Parking Management; Transportation network operations; commercial vehicle operations; public transportation applications; Automated Highway Systems- Vehicles in Platoons –ITS in World – Overview of ITS implementations in developed countries, ITS in developing countries. Case Studies

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Identify and apply ITS applications at different levels
CO2	:	Illustrate ITS architecture for planning process
CO3	:	Examine the significance of ITS for various levels
CO4	:	Compose the importance of ITS in implementations

Reference Books

1. Pradip Kumar Sarkar and Amit Kumar Jain, "Intelligent Transport Systems", PHI Learning Private Limited, Delhi,2018, ISBN-9789387472068
2. Choudury M A and Sadek A, "Fundamentals of Intelligent Transportation Systems Planning" Artech House publishers (31 March 2003); ISBN-10: 1580531601
3. Bob Williams, "Intelligent transportation systems standards", Artech House, London, 2008. ISBN-13: 978-1-59693-291-3
4. Asier Perallos, Unai Hernandez-Jayo, Enrique Onieva, Ignacio Julio García Zuazola "Intelligent Transport Systems: Technologies and Applications" Wiley Publishing ©2015, ISBN:1118894782 9781118894781

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5& 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

Semester: II						
DESIGN AND IMPLEMENTATION OF HUMAN-MACHINE INTERFACE GLOBAL ELECTIVE INDUSTRY ASSISTED ELECTIVE-BOSCH						
Course Code	**:**	MEC325DF		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	40L		**SEE Duration**	**:**	**3Hours**

Unit-I	**08 Hrs**
FOUNDATIONS OF HMI: The Human: History of User Interface Designing, I/O channels, Hardware, Software and Operating environments, The Psychopathology of everyday Things, Psychology of everyday actions, Reasoning and problem solving. The computer: Devices, Memory, processing and networks. Interaction: Models, frameworks, Ergonomics, styles, elements, interactivity, Paradigms. **Introduction to HMI and domains**: Automotive, Industrial, CE, Medical, ECUs within car and their functionalities. Interaction between ECUs. Communication protocols for ECUs(CAN, LIN, Most, FlexRay, Ethernet etc)	
Unit – II	**08 Hrs**
Automotive Human-Machine Interfaces: Automotive infotainment system - Evolution road map, Feature sets, System architecture, Trends, Human factors and ergonomics in automotive design, Automotive User Experience (UX) Design Principles, In-Vehicle Information Systems (IVIS), Driver-Assistance Systems (DAS) Interfaces, HMI design for adaptive cruise control, Voice and Gesture Recognition in Automotive HMIs, Touchscreen Interfaces and Controls, Usability Testing and Evaluation in Automotive HMIs, Safety Considerations and Regulations in Automotive HMIs, Emerging Technologies in Automotive HMIs, Human-Machine Interfaces for Autonomous Vehicles	
Unit –III	**08 Hrs**
UX and Guidelines: Introduction to UX design - stages, theory, Design thinking, UX Study, Interaction concepts, Graphic design tools - Adobe Photoshop, Adobe XD, Blender, GIMP, Asset Design - Overview , Guidelines and norms, 2D/3D rendering, OpenGL, OSG.	
Unit –IV	**08 Hrs**
HMI User Interface: User-centered HMI development process, Basics of Web-Server. Web-based HMI: Basics of TwinCAT and HTML, CSS, JavaScript. **HMI on Mobile**: Four Principles of Mobile UI Design, Benefits of Mobile HMIs, Mobile HMI Development Suites.	
Unit –V	**08 Hrs**
HMI Control Systems: Introduction to Voice-Based HMI, Gesture-Based HMI, Sensor-Based UI controls. **Haptics in Automotive HMI**: Kinesthetic Feedback Systems, Tactile Feedback Systems, Haptics in Multimodal HMI, Automotive Use-Cases **HMI Testing**: Limitations of Traditional Test Solutions, Case - Study: Bosch's HMI validation tool - Graphics Test Systems (GTS). **UI analytics**: Usage patterns, Debugging, Performance Profiling, Use Cases.	

Course Outcomes: After completing the course, the students will be able to:-		
CO1	:	Explain the application of HMIs in various domain
CO2	:	Differentiate various communication protocols used in HMI development.
CO3	:	Describe car multimedia system and hardware and software evolution.
CO4	:	Use various graphic tools and advanced techniques to create UIs

Reference Books

1. Shuo gao, Shuo Yan, Hang Zhao, Arokia Nathan " Touch based HMI; Principles and Applications" Springer Nature Switzerland AG, 1st Edition.
2. Robert Wells, " Unity 2020 by Example: A Project based guide to building 2D, 3D augumented reality and Virtual reality games from sratch" Packt Publishing ltd , edition 2020
3. Ryan Cohen, Tao Wang, "GUI Design and Android Apps" Apress, Berkley, CA, 2014

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
MAXIMUM MARKS FOR THE SEE		**100**

SEMESTER: II						
Course Code	:	MEE325DG	**INTELLIGENT CONTROL TECHNIQUES IN ELECTRICAL DRIVES**	CIE Marks	:	100
Credits L-T-P	:	3-0-0	*(Theory)*	SEE Marks	:	100
Hours	:	45L+45EL=90	*(Interdisciplinary Basket Course-D)*	SEE Duration	:	3 Hours

UNIT - I	**9 Hours**
Fuzzy Logic Systems: Introduction to fuzzy logic, fuzzy Vs crisp set, linguistic variables, membership functions, fuzzy sets and operations on crisp sets and fuzzy sets, Fuzzy relations, operations on fuzzy relation, Cartesian Product of Relation. linguistic variables, fuzzy if then rules, compositional rule of inference, Fuzzy Rule Base and Approximate Reasoning	
UNIT - II	**9 Hours**
Fuzzy Logic Control: Basic concept of fuzzy logic control, relationship to PI, PD and PID control, design of FLC: determination of linguistic values, construction of knowledge base, inference engine, tuning, fuzzification, De-fuzzification methods. Fuzzy Inference Systems (FIS), Construction and Working Principle of FIS, Mamdani FIS models, Takagi-Sugeno-Kang (TSK) fuzzy models and concept of Adaptive Fuzzy control, Examples applicable to Drives.	
UNIT - III	**8 Hours**
Neural network: Fundamental Concept, history and development of neural network principles, Biological Neural Network, Comparison Between Biological Neuron and Artificial Neuron, Important Terminologies of ANN. Basic Models and Advantages of Neural Networks. **Learning methods:** types of learning, supervised, unsupervised, reinforced learning, knowledge representation and acquisition **Theory, architecture and learning algorithm of neural network models:** McCulloc model, Hopfield model, Perceptron Network, Back propagation network.	
UNIT - IV	**8 Hours**
Neural Networks for feedback Control: Identification of system models using neural networks, Model predictive control, feedback linearization and model reference control using neural networks, Neural Network Reinforcement Learning Controller, Radial basis function neural networks, Basic learning laws in REF nets, Recurrent back propagation, CMAC networks and ART networks, Kmeans clustering algorithm. Kohnen's feature maps, pattern recognition & mapping, Examples applicable to Drives.	
UNIT - V	**8 Hours**
Hybrid algorithms: Neuro-fuzzy systems, ANFIS and extreme-ANFIS, derivative free optimization methods. **Genetic algorithms:** introduction, principle of natural selection, Flow chart of simple genetic algorithm, GA operators and parameters. Particle swarm optimization, Solution of typical control problems. Case studies on Application to Electrical Drives.	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Explain the concepts ANN and Fuzzy Logic.
CO2	:	Analyze the techniques involved in ANN and fuzzy logic applications.
CO3	:	Design and model hybrid system with ANN and FL or independent system.
CO4	:	Apply techniques in modern industrial drives and power electronics system.

Reference Books

1. Dr. S. N. Sivanandam and Dr. S. N. Deepa, "Principles of Soft Computing", WILEY publication, 2nd Edition, 2008, ISBN: 9788126527410.
2. John Yen and Reza Langari, "Fuzzy Logic – Intelligence, Control and Information", Pearson Education Inc, 3rd Edition, 2009, ISBN 978-81-317-0534-6.
3. Simon Haykin, "Neural Networks – A Comprehensive Foundation", PH Publisher, 2nd Edition, 1998, ISBN:978-81-203-2373-5.

4. Timothy J. Ross., "Fuzzy Logic with Engineering Applications", John Wiley and Sons, 3rd Edition, 2011, ISBN: 978-0-470-74376-8.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**

Sl.No.	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)

Q.NO.	CONTENTS	MARKS
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMSTER: II						
Course Code	:	MET325DH	**ELECTRONIC NAVIGATION SYSTEMS**	CIE Marks	:	100
Credits L-T-P	:	3-0-0	*(Theory)*	SEE Marks	:	100
Hours	:	45L+45EL=90	*(Interdisciplinary Basket Course-D)*	SEE Duration	:	3 Hours

UNIT - I	**9 Hours**
An Introduction to Radar: Basic Radar, The simple form of the Radar Equation, Radar Block Diagram, Radar Frequencies, Application of radar, Types of Radars. Detection of signals in Noise, Receiver Noise and the Signal-to Noise Ratio, Probability of Detection and False alarm, Introduction to Doppler, MTI, UWB Radars	
UNIT - II	**9 Hours**
Terrestrial Network based positioning and navigation: General Issues of wireless positions location, Fundamentals, positioning in cellular networks, positioning in WLANs, Positioning in Wireless sensor networks.	
UNIT - III	**8 Hours**
Satellite-based navigation systems: Global Navigation satellite systems (GNSS), GNSS receivers.	
UNIT - IV	**8 Hours**
LiDAR: Introduction to LiDAR, context and conceptual discussion of LiDAR, Types of LiDARS, LiDARS Detection modes, Flash LiDAR versus Scanning LiDAR, Monostatic versus Bistatic LiDAR, Major Devices in a LiDAR, LiDAR remote sensing, Basic components and physical principles of LiDAR, LiDAR accuracy and data formats.	
UNIT - V	**8 Hours**
SONAR: Underwater acoustics, applications, comparison with radar, submarine detection and warfare, overcoming the effects of the ocean, sonar and information processing.Transmission of the acoustic signal: Introduction, detection contrast and detection index, transmission equation, equation of passive and active sonar.	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Understand the concepts of Radar, LiDAR, Sonar, terrestrial and satellite based navigation system.
CO2	:	Apply the concepts of radars, LiDAR, Sonar, cellular networks, WLAN, sensor networks and satellites in determining the user position and navigation.
CO3	:	Analyze the different parameters of satellite and terrestrial networks for navigation systems.
CO4	:	Evaluate the Radar, LiDAR, Sonar systems and satellite and terrestrial network based navigation and tracking systems.

Reference Books

1. M. L Skolnik,Introduction to RADAR Systems,3rd edition, 2017,TATA Mcgraw-Hill, ISBN: 978- 0070445338
2. Mark A Richards, James A Scheer, William A Holam,Principles of Modern Radar Basic Principles, 2010, 1st Edition, SciTech Publishing Inc, ISBN:978-1891121524 .
3. Davide dardari, Emanuela Falletti, Marco Luise, Satellite and Terrestrial Radio Positioning techniques- A signal processing perspective, 1st Edition, 2012, Elsevier Academic Press, ISBN: 978-0-12-382084-6.
4. Paul McManamon,LiDAR Technologies and Systems, SPIE press, 2019.
5. Pinliang Dong and Qi Chen,LiDAR Remote Sensing and Applications, CRC Press, 2018, ISBN: 978-1- 4822-4301-7
6. Jean-Paul Marage, Yvon Mori, Sonar and Underwater Acoustics, Wiley, 2013, ISBN: 9781118600658

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**
RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MET325DJ	**VEHICULAR COMMUNICATION ECOSYSTEM**	CIE Marks	:	100
Credits L-T-P	:	3-0-0	*(Theory)*	SEE Marks	:	100
Hours	:	45L+45EL=90	*(Interdisciplinary Basket Course-D)*	SEE Duration	:	3 Hours

UNIT – I — **9 Hours**

Introduction: Basic Principles and Challenges, Past and Ongoing VANET Activities

Standards and Regulations of DSRC
Introduction, Layered Architecture for VANETs, DSRC Regulations, DSRC Physical Layer Standard, DSRC Data Link Layer Standard (MAC and LLC), DSRC Middle Layers.

UNIT – II — **9 Hours**

Physical Layer Considerations for Vehicular Communications: Standards Overview, Wireless Propagation Theory, Channel Metrics, Measurement Theory, Empirical Channel Characterization at 5.9 GHz.

MAC Layer and Scalability Aspects of Vehicular Communication Networks: Challenges and Requirements. MAC Approaches for VANETs, Communication Based on IEEE 802.11p.

UNIT - III — **9 Hours**

MAC Layer and Scalability Aspects of Vehicular Communication Networks Performance Evaluation and Modeling, Aspects of congestion control.
Data Security in Vehicular Communication Networks: Challenges of Data Security in Vehicular Networks, Network, Applications, and Adversarial Model, Security Infrastructure, Cryptographic Protocols.

UNIT - IV — **9 Hours**

Intra-vehicle communication:- In-vehicle networks, Automotive bus systems, In-vehicle Ethernet, Wireless in-vehicle networks
Inter-vehicle communication: Applications, Requirements and components, Concepts for inter-vehicle communication, Fundamental limit.

UNIT - V — **9 Hours**

Cooperative Vehicular Safety Applications: Introduction, Enabling technologies, Cooperative system architecture, Mapping for safety applications.
VANET-enabled Active Safety Applications: Infrastructure-to-vehicle applications, Vehicle-to-vehicle applications, Pedestrian-to-vehicle applications.

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Illustrate fundamentals of wireless vehicular networks.
CO2	:	Design of Physical & MAC layer and routing protocols for vehicular networks.
CO3	:	Analyse the security issues and energy management in vehicular networks.
CO4	:	Evaluate the performance of vehicular networks in different use cases.

Reference Books

1. Hannes Hartenstein and Kenneth Laberteaux (eds.), VANET Vehicular Applications and Inter-networking Technologies, John Wiley & Sons, 2009.
2. Christophe Sommer and Falko Dressler, Vehicular Networking, Cambridge University Press, 2014.
3. Claudia Campolo, AntonellaMolinaro and Riccardo Scopigno, Vehicular ad hoc Networks: Standards, Solutions, and Research, Springer, 2015.
4. Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2005.
5. Hannes Hartenstein and Kenneth Laberteaux (eds.), VANET Vehicular Applications and Inter-networking Technologies, John Wiley & Sons, 2009.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**
RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**
RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MIM325DK	**ESSENTIALS OF PROJECT MANAGEMENT**	CIE Marks	:	100
Credits L-T-P	:	3-0-0	*(Theory)*	SEE Marks	:	100
Hours	:	45L+45EL	*(Interdisciplinary Elective)*	SEE Duration	:	3 Hours

UNIT - I	**9 Hours**
Introduction: Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS), Introduction to Agile Methodology.	
UNIT - II	**9 Hours**
Capital Budgeting: Capital Investments: Importance and Difficulties, phases of capital budgeting, levels of decision making, facets of project analysis, feasibility study – a schematic diagram, objectives of capital budgeting	
UNIT - III	**9 Hours**
Project Costing: Cost of Project, Means of Finance, Cost of Production, Working Capital Requirement and its Financing, Profitability Projections, Projected Cash Flow Statement, Projected Balance Sheet, Multi-year Projections, Financial Modeling, Social Cost Benefit Analysis	
UNIT - IV	**9 Hours**
Tools & Techniques of Project Management: Bar (GANTT) chart, bar chart for combined activities, logic diagrams and networks, Project evaluation and review Techniques (PERT) Critical Path Method (CPM), Computerized project management.	
UNIT - V	**9 Hours**
Project Management and Certification: An introduction to SEI, CMMI and project management institute USA – importance of the same for the industry and practitioners. PMBOK 6 - Introduction to Agile Methodology, hemes / Epics / Stories, Implementing Agile. Domain Specific Case Studies on Project Management: Case studies covering project planning, scheduling, use of tools & techniques, performance measurement.	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Explain project planning activities that accurately forecast project costs, timelines, and quality.
CO2	:	Evaluate the budget and cost analysis of project feasibility.
CO3	:	Analyze the concepts, tools and techniques for managing projects.
CO4	:	Illustrate project management practices to meet the needs of Domain specific stakeholders from multiple sectors of the economy (i.e. consulting, government, arts, media, and charity organizations).

Reference Books

1. Prasanna Chandra, Project Planning Analysis Selection Financing Implementation & Review, Tata McGraw Hill Publication, 9th Edition, 2017, ISBN: 978-9332902572.
2. Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK Guide), 5th Edition, 2013, ISBN: 978-1-935589-67-9
3. Harold Kerzner, Project Management A System approach to Planning Scheduling & Controlling, John Wiley & Sons Inc., 11th Edition, 2013, ISBN 978-1-118-02227-6.
4. Rory Burke, Project Management – Planning and Controlling Techniques, John Wiley & Sons, 4th Edition, 2004, ISBN: 978-0470851241

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER : II						
Course Code	**:**	**MIS325DM**	**USER INTERFACE AND USER EXPERIENCE**	**CIE Marks**	**:**	**100**
Credits L-T-P	**:**	**3-1-0**	***(Theory)***	**SEE Marks**	**:**	**100**
Hours	**:**	**39+13**	***(Interdisciplinary Basket Course-D)***	**SEE Duration**	**:**	**3 Hours**

UNIT - I — **8 Hours**

What's a UI Pattern: How Users Interact With Design Patterns, Following Universal Design Conventions, Applying Empathy to UI Design Patterns. Why Use UI Patterns?: Why Patterns Work, Expectations Reinforce Themselves, Deadline-Busting Communication, Why not use patterns?. The Importance of Prototyping First: Got a Pattern? Plan it Out, Thinking Through the Process, Patterns Take Guesswork Off of Developers' Plates.

UNIT - II — **8 Hours**

User Testing: Insights You Can't Ignore. Prototyping UI Patterns: Explaining the Gray Box, Pattern Libraries Are Prototyping Shortcuts, Reusable elements, Patterns and Prototypes Work Together, Applying UI Design Patterns: Building a Pattern Library, Riffing on Design Patterns, Tweaking Pattern Styles, Going forward, Useful UI Pattern Examples, Formatting Data, Getting input, Navigation, Teasers.

UNIT - III — **8 Hours**

Design for Usefulness: Painkillers & Vitamins, Embracing Goal-Centered Design, Test for Relevancy With an MVP, A Quick MVP Case Study: Buffer. Designing for Usability: Forgiving, Satisfying, The 6-Step Process to Improve Usability. Designing for Desirability: Desirable Products Are More Usable, Desire Is Relative to Users, Elements of Desirable Design.

UNIT - IV — **8 Hours**

Designing for Findability: Building the Right Information Architecture, 5 IA Layouts for the Web, 5 Navigational Menu Patterns, Testing Findability. Designing for Accessibility: Universal Design, What Accessibility Means for UX Design, Benefits of Accessibility, Accessibility Best Practices

UNIT - V — **7 Hours**

The Core of Desirable Design: The Habit Loop, A Quick Case Study, Quick Case Study: Apple.com. Designing for Credibility: First Impressions Matter, Quick Case Study: Chase, Building a Credible Product Interface, Selling the Product Through Social Proof, Persuading Through Transparency.

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Apply the concept of User Interface and User Experience to increase look and feel various applications.
CO2	:	Analyse the usability, accesssibility, availability and other factors of User Interface design patterns.
CO3	:	Design and implement techniques of implementing design patterns.
CO4	:	Evaluate the design patetrns and elements of user experience.

Reference Books

1. Ben Gremillion, Jerry Cao, Kamil, Tactical UI Design Patterns, The Handbook to faster Design, UXPin Inc., 2015.
2. Jerry Cao, Kamil, Matt Ellis, The Elements of Successful UX Design, Best Practices of Meaningful products, UXPin Inc., 2015.
3. User Friendly- How the Hidden Rules of Design Are Changing the Way We Live, Work, and Play, Cliff Kuang, Picador Paper; Reprint edition, 2020, ISBN: 1250758203
4. Jenifer Tidwel, Designing Interfaces: Patterns for Effective Interaction Design, 3rd Edition, O'Reilly, 2020, ISBN: 1492051969

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MMA325DN	**MATHEMATICAL METHODS FOR DATA SCIENCE**	CIE Marks	:	100
Credits L-T-P	:	3-0-0	*(Theory)*	SEE Marks	:	100
Hours	:	45L+45EL	*(Interdisciplinary Basket Course-D)*	SEE Duration	:	3 Hours

UNIT - I	**9 Hours**
Parameter Estimation: Introduction to probability models of univariate random variables, Discrete distribution (Bernoulli, Binomial, Poisson), Continuous distributions (Uniform, Exponential, Normal), Estimation - Criteria for good estimates - unbiasedness, consistency, efficiency and sufficiency, Variance of a point estimator, Parameter estimation via maximum likelihood, Method of moments, Bayesian estimation of parameters.	
UNIT - II	**9 Hours**
Optimization I: Introduction and formulation, Optimality conditions, Review of local maxima, and local minima along with first and second order conditions. Taylor series and local function approximation, automatic differentiation, One dimensional Search Methods - Sequential search method, Fibonacci search method, Golden section search method.	
UNIT - III	**9 Hours**
Optimization II: Constrained and Unconstrained optimization, Gradient vector, Hessian matrix, optimization using Hessian matrix, Gradient descent method, Step size selection and convergence, Newton method, Stochastic gradient descent (SGD), Convex optimization, Duality - weak and strong duality, Optimization using duality.	
UNIT - IV	**9 Hours**
Fuzzy Optimization: Basic concepts of fuzzy sets - Operations on fuzzy sets, Fuzzy relation equations, Fuzzy logic control, Fuzzification, Defuzzification, Decision making logic, Membership functions. **Artificial Neural Networks:** Introduction - Neuron model, Multilayer perceptions - Back propagation algorithm and its variants, Loss functions in artificial neural networks.	
UNIT - V	**9 Hours**
Machine Learning Algorithms: Unsupervised learning, Supervised learning, Linear regression, Multiple Linear Regression, Overfitting, Naïve Bayes classifier. Clustering methods, k-means clustering, Linear support vector machine, Kernel functions and Nonlinear support vector machine.	

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Explore fundamental concepts of estimation, optimization, and machine learning applied in various branches of engineering. **(PO1, PO4, PO6)**
CO2	:	Apply theoretical concepts of estimation and optimization to model problems using a machine learning approach on model requirements and to evaluate solutions within given constraints effectively. **(PO1, PO2, PO4, PO6)**
CO3	:	Analyze and solve the modern engineering problems using appropriate techniques of statistical and mathematical learning to the real-world problems arising in many practical situations. **(PO1, PO3, PO4, PO6)**
CO4	:	Develop and implement algorithms for constrained and unconstrained optimization, utilizing estimation techniques to classify, predict, and optimize solutions for practical applications, emphasizing model accuracy and performance and also engage in lifelong learning. **(PO1, PO2, PO3, PO4, PO6)**

Reference Books
1. Jorge Nocedal Stephen J. Wright, Numerical Optimization, Springer, 2nd Edition, 2006, ISBN-10: 0-387-30303-0 ISBN-13: 978-0387-30303-1.
2. Mykel J. Kochenderfer, Tim A. Wheeler, Algorithms for Optimization, MIT Press, Illustrated Edition, 2019, ISBN-13 978-0262039420.
3. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 1st Edition, 2006, ISBN-10: 0-387-31073-8 ISBN-13: 978-0387-31073-2.
4. Shai Shalev-Shwartz and Shai Ben-David "Understanding Machine Learning: From Theory to Algorithms", 1st Edition, Cambridge University Press, 2014, ISBN: 978-1-107-05713-5.
5. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications**,** 1st Edition, Prentice Hall PTR, 1995, ISBN 0-13-101171-5.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **THREE quizzes** will be conducted (Two regular quizzes and one optional improvement quiz) & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **THREE** tests will be conducted (Two regular tests and one optional improvement test). Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**
RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II						
Course Code	:	MME325DO	**INDUSTRY 4.0: THE SMART MANUFACTURING**	CIE Marks	:	100
Credits L-T-P	:	3-0-0	***(Theory)***	SEE Marks	:	100
Hours	:	45L+45EL = 90	***(Interdisciplinary Basket Course-D)***	SEE Duration	:	3 Hours

UNIT – I — **9 Hours**

Fundamentals of Industry 4.0-Introduction, Key Components of Industry 4.0, RAMI 4.0, Cyber-Physical Systems.
Servitization and Product-Service Systems - Integrated Overview, Examples Across Sectors.
Industry 4.0 Across Sectors- Introduction, Smart Manufacturing, Transportation 4.0, Multimodal Transportation Systems, Rail 4.0, Logistics 4.0 and Implications.
Future Trends and Challenges- Emerging Applications, Risks and Barriers to Implementation

UNIT – II — **9 Hours**

The Concept of IIoT- Introduction to IIoT, Key Features and Applications
Modern Communication Protocols- Overview, TCP/IP, Wireless Communication, Technologies.
API- A Technical Perspective, Importance in IIoT, Examples and Applications, **Middleware**
Architecture- Role in IIoT, Integration and Data Flow Management.
Emerging Trends in IIoT- Industrial IoT Standards and Frameworks, Edge Computing in IIoT.

UNIT – III — **8 Hours**

Data Analytics in Manufacturing: Energy Efficiency in Manufacturing, Anomaly Detection in Air Conditioning Systems, Smart Remote Machinery Maintenance Systems with Komatsu, Quality Prediction in Steel Manufacturing, Predictive Maintenance with Data Analytics
Internet of Things and New Value Proposition: IoT in Manufacturing, Value Creation Barriers: Standards, security, and privacy concerns.
Advances in Robotics in the Era of Industry 4.0: Recent Technological Components of Robots, Advanced Sensor Technologies, Artificial Intelligence in Robotics, Collaborative Robots, Internet of Robotic Things, Cloud Robotics, Digital Twin Technology

UNIT – IV — **8 Hours**

Additive Manufacturing Technologies and Applications: Additive Manufacturing Technologies Overview, Stereo lithography, 3D Printing, Fused Deposition Modeling, Selective Laser Sintering, Laser Engineered Net Shaping, Manufacturing in Industry 4.0, Hybrid Manufacturing Processes.
Advances in Virtual Factory Research and Applications: The State of Art, The Virtual Factory Software

UNIT – V — **8 Hours**

Cybersecurity and Resilience in Industry 4.0: Introduction to Cybersecurity in Industry 4.0, Industrial IoT security, Edge and Cloud Security, Digital Twin Security, AI and Machine Learning for Cybersecurity, Standards and Frameworks for Industry 4.0 Cybersecurity, Resilience Strategies for Industry 4.0, Future Trends in Cybersecurity for Industry 4.0

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Understand the opportunities, challenges brought about by Industry 4.0 for benefits of organizations and individuals
CO2	:	Analyze the effectiveness of Smart Factories, Smart cities, Smart products and Smart services
CO3	:	Apply the Industrial 4.0 concepts in a manufacturing plant to improve productivity and profits
CO4	:	Evaluate the effectiveness of Cloud Computing in a networked economy

Reference Books

1. Alasdair Gilchrist, Industry 4.0 The Industrial Internet Of Things, Apress Publisher, ISBN-13 (pbk): 978-1-4842-2046-7
2. Alp Ustundag, Emre Cevikcan, Industry 4.0: Managing The Digital Transformation, Springer, 2018 ISBN 978-3-319-57869-9
3. Ovidiu Vermesan and Peer Friess, Designing the industry - Internet of things connecting the physical, digital and virtual worlds, Rivers Publishers, 2016 ISBN 978-87-93379-81-7

4. Christoph Jan Bartodziej, The concept Industry 4.0- An Empirical Analysis of Technologies and Applications in Production Logistics, Springer Gabler, 2017 ISBN 978-3-6581-6502-4

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**

Sl. No.	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)

Q.NO.	CONTENTS	MARKS
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
	MAXIMUM MARKS FOR THE SEE	**100**

SEMESTER: II

Course Code	:	**MME325DQ**	**INDUSTRIAL INTERNET OF THINGS (IIOT)**	CIE Marks	:	100
Credits L-T-P	:	3-0-0	(Theory)	SEE Marks	:	100
Hours	:	45L+45EL=90	*(Interdisciplinary Basket Course-D)*	SEE Duration	:	3 Hours

UNIT – I **9 Hours**

Introduction:
IoT vs IIoT, challenges in deployment, building blocks of business model and architecture, layers, sensing for manufacturing process, processing, communication and networking. Applications – Factories and assembly lines, inventory management and quality control, facility management.

Industrial Control Systems
Process Industries versus Discrete Manufacturing Industries – Levels, variables and parameters, Continuous Control Systems, Discrete Control Systems, Computer Process Control - Control Requirements, Capabilities of Computer Control, Forms of Computer Process Control.

UNIT – II **9 Hours**

Sensors in IIoT applications
Temperature sensor interfacing, accelerometer sensor interfacing, MoS Gas sensor, magneto strictive sensors, speed sensor, ultrasonic sensor, smart sensors.

Automatic identification and data Capture
Overview Of Automatic Identification Methods, Linear (One-Dimensional) Bar Code, Two-Dimensional Bar Codes, Radio Frequency Identification, Magnetic Stripes, Optical Character Recognition, Machine Vision

UNIT – III **8 Hours**

Group Technology and Cellular Manufacturing
Part Family, Intuitive Grouping, Parts Classification and Coding, Production Flow Analysis, cellular manufacturing - Composite Part Concept, Machine Cell Design, applications of group technology, Opitz Part Coding System, Machine Cell Organization and Design Rank-Order Clustering - Numericals

UNIT – IV **8 Hours**

Industrial Networking
Introduction, Hierarchy of Industrial Networks, Network Topologies, Data Flow Management, Transmission Hardware, Network Backbones, Network Communication Standards, Fieldbus Networks

Simulating Industrial Processes
Queues and Queueing – waiting time, service time, machine utilization, Modelling an Industrial Process Designing a Process Simulation, managing resource utilization, product mixes, Queuing network models.

UNIT – V **8 Hours**

Clustering
Similarity measures, hierarchical clustering – single linkage, complete linkage, average linkage Nonh ierarchical clustering – Numericals, multidimensional scaling correspondence analysis - Numericals

Prediction Models
K- Nearest neighbour, RMS Error and Mean Absolute Error, Mean Absolute Percentage Error, Coefficient of Determination, Underfitting and Overfitting, Cross-Validation, multiple regression – Numericals.

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Analyze the differences between IoT and IIoT, and evaluate the challenges, architectures, and sensing layers involved in the deployment of IIoT for manufacturing and industrial applications.
CO2	:	Demonstrate the ability to interface sensors in IIoT systems, and apply automatic identification techniques for process automation.
CO3	:	Design machine cells using group technology principles, and implement cellular manufacturing systems for optimized production workflows.
CO4	:	Develop simulation models for industrial processes, and predict outcomes to optimize industrial system performance.

Reference Books
1. Jeschke, S., Brecher, C., Song, H., & Rawat, D. B. (Eds.). (2017). Industrial Internet of Things: Cyber manufacturing Systems. Springer. ISBN: 978-3-319-42559-7.
2. Groover, M. P. (2018). Automation, Production Systems, and Computer-Integrated Manufacturing (5th ed.). Pearson. ISBN: 978-0134605463.
3. Johnson, R. A., & Wichern, D. W. (2007). Applied Multivariate Statistical Analysis (6th ed.). Pearson Prentice Hall. ISBN: 978-0131877153.
4. Hill, R., & Berry, S. (2021). Guide to Industrial Analytics: Solving Data Science Problems for Manufacturing and the Internet of Things. Springer. ISBN: 978-3-030-79103-2

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)		
CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**		
Sl.No.	**COMPONENTS**	**MARKS**
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MARKS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
MAXIMUM MARKS FOR THE SEE		100

SEMESTER: II						
Course Code	:	MIM426RT	**RESEARCH METHODOLOGY**	CIE Marks	:	NA
Credits L-T-P	:	2-0-0	*(Theory - NPTEL Online Course)*	SEE Marks	:	100
Hours	:	16 L	*(Common Course to all M.Tech Programs)*	SEE Duration	:	3 Hours

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: A group discussion on what is research; Overview of research
Week 2: Literature survey, Experimental skills
Week 3: Data analysis, Modelling skills
Week 4: Technical writing; Technical Presentations; Creativity in Research
Week 5: Creativity in Research; Group discussion on Ethics in Research
Week 6: Design of Experiments
Week 7: Intellectual Property
Week 8: Department specific research discussions

Reference Books:

1. Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Integration of Principles, Methods and Techniques, 17th Impression, Pearson India Education Services Pvt. Ltd, 2018. ISBN: 978-81-7758-563-6 2.
2. William M. K. Trochim, James P. Donnelly, The Research Methods Knowledge Base, 3rd Edition, Atomic Dog Publishing, 2006, ISBN: 978-1592602919 3.
3. Kothari C.R., Research Methodology Methods and Techniques, 4th Edition, New Age International Publishers, 2019, ISBN: 978-93-86649-22-5. 4.
4. Levin, R.I. and Rubin, D.S., Statistics for Management, 8th Edition, Pearson Education: New Delhi, 2017, ISBN13- 978-8184957495

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
2. NPTEL is offering online certification courses through its portal -https://swayam.gov.in/nc_details/NPTEL
3. Enrollment to courses and exam registration can be done in ONLINE mode only. The link is available on NPTEL website http://nptel.ac.in/
4. Students need to enroll for the NPTEL course and clear the exam.
5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL.

SEMESTER: II						
Course Code	:	MBT427DL	**DESIGN THINKING LABORATORY**	CIE Marks	:	50
Credits L-T-P	:	0-0-2		SEE Marks	:	50
Hours	:	30P	*(Design Thinking /Skill Laboratory)*	SEE Durations	:	3 Hrs
Content						**30 Hrs**

STAGE–I
Empathy: The Empathy phases of the process are focused on understanding the experiences, emotions and motivations of others. Designers use specific empathy methods to learn more about the needs of the users for whom they are designing. Empathy is the centerpiece of a human-centered design process. The Empathize mode is the work you do to understand people, within the context of your design challenge. Methods: Interviewing Probes, survey and Observations.

STAGE–II
Define: The Define phase of the process is focused on developing a point of view about the need of your user. During this stage of process, designers narrow from lots of information to a statement that is inspiring and specific. Methods: Empathy Mapping, Point of View.

STAGE–III
Ideate: The Ideate phase of the process is focused on generating as many solutions to a problem as possible. Once many solutions have been generated, students will select one to move forward to prototyping. Methods: Brainstorming and Selection

STAGE–IV
Prototype: The Prototype phase is where designers construct representation of their solutions. These representations are intended to elicit feedback and answer specific questions about a concept. Methods: Improve, Rapid and Experiential Prototyping

STAGE–V
Test: The Test phase of the process is focused on getting specific feedback about how ideas can improve. It is important to remember during this phase that prototypes are imperfect, but feedback is gift. Methods: Testing

Guidelines for Design Thinking Lab:

1) The Design Thinking Lab (DTL) is to be carried out by a team of two-three students.

2) Each student in a team must contribute equally in the tasks mentioned below.

3) Each group has to select a theme that will provide solutions to the challenges of societal concern. Normally three to four themes would be identified by the department

4) Each group should follow the stages of Empathy, Design, Ideate, Prototype and Test for completion of DTL.

5) After every stage of DTL, the committee constituted by the department along with the coordinators would evaluate for CIE. The committee shall consist of respective coordinator & two senior faculty members as examiners. The evaluation will be done for each student separately.

6) The team should prepare a Digital Poster and a report should be submitted after incorporation of any modifications suggested by the evaluation committee.

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Apply the knowledge of engineering and technology to empathize with the stake holder requirements and draw insights through effective communication
CO2	:	Formulate, analyze and ideate sustainable solutions considering societal and environmental needs, aligning with SDGs
CO3	:	Validate the knowledge effectively and pursue through intra-disciplinary or interdisciplinary teams to develop prototypes/ pretotypes
CO4	:	Apply 21st century skills and Education 4.0 to enhance the solutions and engage in lifelong learning

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION

Phase	Activity	Marks
1.	Empathy and Define Phase	**20**
2.	Ideate Phase	**20**
3.	Prototype & Testing Phase	**10**
	MAXIMUM MARKS FOR THE CIE	**50**

RUBRIC FOR SEMESTER END EXAMINATION

Q.NO.	CONTENTS	MARKS
1.	Write Up	**10**
2.	Presentation and Demonstration	**30**
3.	Viva	**10**
	TOTAL	**50**

SEMESTER: III						
Course Code	:	MBT331TA	**NEW BIOPHARMACEUTICALS, DESIGN AND DEVELOPMENTS**	CIE Marks	:	100
Credits L-T-P	:	3- 1 – 0		SEE Marks	:	100
Hours	:	45L+45EL+30T	*Professional Core - 5*	SEE Durations	:	3 Hrs

UNIT - I **9 Hrs**

Bioavailability and bioequivalence studies: Designing of bioavailability and bioequivalence studies and interpretation of results. Physicochemical properties affecting bioavailability, pH-partition theory, dissolution, surface area adsorption, complexation, polymorphism and techniques of enhancing dissolution rate. Details on Pharmacopoeia Regulatory requirements: Generic Drug Product development, Hatch-Waxman Act, Regulatory requirements for product approvals: Clinical research process, IND, NDA, ANDA, SUPAC, Post marketing surveillance. Generic Drug
Product development

UNIT - II **9 Hrs**

Facility design, unit operations and manufacturing: Structure Activity Relationship - QSARs and QSPRs, QSAR Methodology, Various Descriptors used in QSARs. Temperature and humidity controls, Air control, HEPA. Schedule M, Schedule Y layout setup, facilities, Identification and characterization of impurities in pharmaceutical substances. Limit tests: Definition, importance, general procedure for limit test for chlorides, sulphates, iron, arsenic, heavy metals, lead and modifications with suitable examples. GMP, GLP, fundamentals of pharmaceutical quality by design, identification of critical quality attributes, critical material attributes, critical process parameters and quality risk management

UNIT - III **9 Hrs**

Drug Delivery System: Oral, Sublingual, Buccal, Parenteral, Topical, Rectal and Inhalation. The pharmacokinetic implications of various routes of administration- Advantages and Disadvantage of various routes of administration. Drug Pharmacokinetics and Pharmacodynamics: Carriers for the active transport of drugs (With special emphasis on p-glycoprotein & design of pgp inhibitors. Drug Absorption Barriers: Extracellular barriers, Intracellular barriers, Study of cell penetrating peptides and fusogenic peptides. Drug Pharmacodynamics.

Introduction to the different pathways of drug metabolism: Phase I and II reactions, sites of drug metabolism, subcellular localization of drug metabolizing enzymes, cofactors required for catalytic reactions. basic pharmacokinetic parameters like Volume of distribution, Elimination half life, Elimination rate constant.

UNIT - IV **9 Hrs**

Introduction to Vaccinology: Classification, active immunization, means of passive immunization, antibodies in therapy, antibody engineering, immunoconjugates - specific drug targeting, immunotoxins. Immuno-Therapeutics:

Development of immuno-drugs. Cytokines classification, pathways of activation, Therapeutic use of cytokines. Immunomodulators classification, thymic hormones and synthetic immune-stimulators.
Compliment pathways diagnostics, Basic immunotoxicology - Principles of testing of immune-moderating drugs and Xenobiotics.

Food as Remedies: Nutraceuticals bridging the gap between food and drug, Nutraceuticals in treatment for cognitive decline, Nutraceutical remedies for common disorders like Arthritis, Bronchitis, circulatory problems, hypoglycemia, Nephrological disorders, Liver disorders, Osteoporosis, Psoriasis and Ulcers etc.

Brief idea about some Nutraceutical rich supplements e.g. Bee pollen, Caffeine, Green tea, Lecithin, Mushroom extract, Chlorophyll, Kelp and Spirulina etc Probiotics and Prebiotics.

UNIT – V **9 Hrs**

Drug Pharmacology: Chemical transmission and drug action in the CNS. Diuretics, Drugs altering the pH of urine, excretion of organic molecules.Molecular Cardiology: Congenital Heart Disease, Inherited Cardiomyopathies, Coronary Atherosclerosis, Derived Nitric Oxide and Control of Vascular Tone, Hypertension, Cardiac Arrhythmias, Cardiovascular Gene Therapy. Pulmonology: Asthma, Pulmonary Emphysema. Lung Cancer: The Role of Tumor Suppressor Genes.
Strategies for controlling the diseases. Drugs acting on GIT: Antacids and anti-ulcer drugs, Laxatives and Anti-diarrheal drugs, Appetite stimulants and suppressants, Emetics and anti-emetics. Thyroid hormones and anti-thyroid drugs ACTH and corticosteroids, Androgens and anabolic steroids, oral contraceptives.
Treatment of poisoning, Heavy metals and heavy metal antagonists, Acute, Sub acute and Chronic toxicity

Course Outcomes: After going through this course, the student will be able to:		
CO1	:	Understand the basic importance and of various pharmaceutical products and their development
CO2	:	Evaluate the manufacturing, quality control and associated regulatory requirements of pharmaceutical products
CO3	:	Apply knowledge and understanding towards drug release, interactions and related mechanism with various human populations based on experimental design.
CO4	:	Describe approved biotech products, e.g., indications, advantages, disease impact, & product limits, & status of pipeline products, e.g., development issues

Reference Books

1. Udupa, N., Bhat, K. A Concise Textbook of Drug Regulatory Affairs; 1st ed.; Manipal University Press, Manipal, India (2023).
2. Lachman/Lieberman's The Theory and Practice of Industrial Pharmacy; 4th ed.; Khar, R. K., Vyas, S. P., Ahmad, F. J., Jain, G. K., Eds; CBS Publishers and Distributors, Pvt. Ltd., New Delhi, India (2023)
3. Dosage Form Design Parameters. Advances in Pharmaceutical Product Development and Research Series, Vol. II; Tekade, R. K., Ed.; Academic Press, London, UK (2018)
4. Goodman & Gilman's: The Pharmacological Basis of Therapeutics, 14th Edition, ISBN 978-1-264-25807-9 MHID 1-264-25807-0, (2023)

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (CIE-Theory)

CIE will consist of TWO Quizzes (Q), TWO Tests (T), and ONE Experiential Learning (EL) component **[20 (Q) + 40 (T) + 40 (EL) = 100 marks)**

Sl.No.	COMPONENTS	MA RKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & each Quiz will be evaluated for 10 marks, and Final Quiz marks adding up to 20 marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**20**
2.	**TESTS:** Students will be evaluated in test consisting of descriptive questions with different complexity levels (Revised Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). **TWO TESTS** will be conducted. Each test will be evaluated for 50 Marks, adding up to 100 Marks. **FINAL TEST MARKS WILL BE REDUCED TO 40 MARKS.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. **Phase I (20) & Phase II (20) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE	**100**

RUBRIC FOR SEMESTER END EXAMINATION (SEE-Theory)		
Q.NO.	**CONTENTS**	**MAR KS**
1 & 2	Unit 1: Question 1 or 2	20
3 & 4	Unit 2: Question 3 or 4	20
5 & 6	Unit 3: Question 5 or 6	20
7 & 8	Unit 4: Question 7 or 8	20
9 & 10	Unit 5: Question 9 or 10	20
MAXIMUM MARKS FOR THE SEE		**100**

SEMESTER: III						
Course Code	:	MBT332E1	**BIOLOGICAL DATA ANALYSIS AND VISUALIZATION WITH R**	CIE Marks	:	NA
Credits L-T-P	:	2-0-0	*(Theory - NPTEL Course online)*	SEE Marks	:	100
Hours	:	16 L	*Professional Elective Courses (NPTEL) (Group-E)*	SEE Duration	:	3 Hours

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: Introduction and set up for biological data analysis with R
Week 2: Basic statistical analysis and data visualization techniques
Week 3: Bioconductor packages
Week 4: Gene expression analysis and co-expression network
Week 5: Analysis of ChIP-seq data in R
Week 6: Regression models on biological data
Week 7: Dimensionality reduction techniques
Week 8: Decision trees and Random Forest

Course duration: 8 Weeks
Course start Date: Jan 20,2025 (Tentative)
Course end date: March 14,2025
Probable Exam date: March 22,2025
Course Instructors: Prof. Riddhiman Dhar, Department of Biotechnology, IIT Kharagpur

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
2. NPTEL is offering online certification courses through its portal -https://swayam.gov.in/nc_details/NPTEL
3. Enrollment to courses and exam registration can be done in ONLINE mode only. The link is available on NPTEL website http://nptel.ac.in/
4. Students need to enroll for the NPTEL course and clear the exam.
5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL

SEMESTER: III						
Course Code	:	MBT332E2	**BIOSTATISTICS AND DESIGN OF EXPERIMENTS**	CIE Marks	:	NA
Credits L-T-P	:	2-0-0	*(Theory - NPTEL Course online)*	SEE Marks	:	100
Hours	:	16 L	*Professional Elective Courses (NPTEL) (Group-E)*	SEE Duration	:	3 Hours

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: Introduction, Experimental design strategy, Data types/Binomial Distribution poisson Distribution, Normal Distribution

Week 2: Standardized Normal Distribution/ t distribution, t distribution/confidence interval Statistical tests, t- tests, t- tests – continued

Week 3: t- tests – continued, F- tests, F- tests –continued ANOVA, ANOVA-continued

Week 4: ANOVA-continued

Week 5: NORMALITY TEST/ODDS RATIO, c2 distribution/test, c2 distribution/test –continued, c2 test, Weibull distribution

Week 6: Weibull distribution-contniued, Weibull distribution-continued, Nonparametric tests Non parame--tric tests/Homogeneity of variance/Beta distribution, Exponential / Hypergeometric distributions

Week 7: Hypergeometric/Log normal distributions, Design of Experiments (DOE) – Introduction, Factorial design, Full Factorial design, Fractional Factorial design

Week 8: Other designs, Second order designs, Second order designs-continued Regression Analysis Control Charts

Course duration: 8 Weeks
Course start Date: Jan 20,2025 (Tentative)
Course end date: March 14,2025
Probable Exam date: March 22,2025
Course Instructors: Prof. Mukesh Doble, Department of Biotechnology, IIT Madras

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
2. NPTEL is offering online certification courses through its portal -https://swayam.gov.in/nc_details/NPTEL
3. Enrollment to courses and exam registration can be done in ONLINE mode only. The link is available on NPTEL website http://nptel.ac.in/
4. Students need to enroll for the NPTEL course and clear the exam.
5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL

SEMESTER: III						
Course Code	:	MBT332E3	**INTRODUCTORY MATHEMATICAL METHODS FOR BIOLOGISTS**	CIE Marks	:	NA
Credits L-T-P	:	2-0-0	*(Theory - NPTEL Course online)*	SEE Marks	:	100
Hours	:	16 L	*Professional Elective Courses (NPTEL) (Group-E)*	SEE Duration	:	3 Hours

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: Introduction, Graphs and Functions
Week 2: Functions and its derivatives, computing derivatives of curves
Week 3: Plotting curves, Numerical calculation of derivatives, partial derivatives
Week 4: Integration and their graphical understanding
Week 5: Vectors: Position and movement in 2D cell symmentry: Use of polar Coordinates
Week 6: Gradient, Forces and flows, Understanding diffusion
Week 7: Introduction to Fourier series, Fourier Transform and statistics
Week 8: Basics of Bio statiscs

Course duration: 8 Weeks
Course start Date: Jan 20,2025 (Tentative)
Course end date: March 14,2025
Probable Exam date: March 22,2025
Course Instructors: Prof. Ranjit Padinhateeri, Department of Biosciences and Bioengineering IIT Bombay

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
2. NPTEL is offering online certification courses through its portal -https://swayam.gov.in/nc_details/NPTEL
3. Enrollment to courses and exam registration can be done in ONLINE mode only. The link is available on NPTEL website http://nptel.ac.in/
4. Students need to enroll for the NPTEL course and clear the exam.
5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL

SEMESTER: III						
Course Code	:	MBT332E4	**MEDICAL BIOMATERIALS**	CIE Marks	:	NA
Credits L-T-P	:	2-0-0	*(Theory - NPTEL Course online)*	SEE Marks	:	100
Hours	:	16 L	*Professional Elective Courses (NPTEL) (Group-E)*	SEE Duration	:	3 Hours

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: Introduction to Biomaterials: Background history, History, Properties (Mechanical and Physico-chemical) Properties (Mechanical and Physico-chemical)

Week 2: Mechanical properties, Resorbability, biodegradation, Biofilm
Week 3: Biofilm, Material characterization - Analytical instruments
Week 4: Analytical instruments, Biological responses, compatibility, cytotoxicity Proteins, Tissue and blood Response Cell-biomaterial interaction Ceramics
Week 5: Animal trials, Metals-types, classifications, applications,. Metals – properties
Week 6: Metals Polymers-types, classifications, applications Polymers
Week 7: Blends/composites, Biopolymers Hydrogels, Preparation of different morphologies (with experiments) Surface modifications (with experiments)
Week 8: Ceramics, Drug delivery systems/encapsulation, Biomaterials for cardiovascular / pulmonary / ophthalmological applications, Biomaterials for urinary/dental/skin applications, Sterilization of implants, device failures, unique issues, conclusion

Course duration: 8 Weeks
Course start Date: Jan 20,2025 (Tentative)
Course end date: March 14,2025
Probable Exam date: March 22,2025
Course Instructors: Prof. Mukesh Doble, Department of Biological Sciences & Bioengineering IIT, Madras

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
2. NPTEL is offering online certification courses through its portal -https://swayam.gov.in/nc_details/NPTEL
3. Enrollment to courses and exam registration can be done in ONLINE mode only. The link is available on NPTEL website http://nptel.ac.in/
4. Students need to enroll for the NPTEL course and clear the exam.
5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL

SEMESTER: III						
Course Code	:	MBT433MP	**MINOR PROJECT**	CIE Marks	:	50
Credits L-T-P	:	0-0-6		SEE Marks	:	50
Hours/Week	:	12		SEE Duration	:	3 Hours

Guidelines

1. Student can form group of two to execute the Minor Project.
2. Students are required to select topics related to their PG Program Specialization after extensive Literature Survey and analyzing the Research gaps.
3. Students will be assigned to guides in accordance with the expertise of the faculty.
4. Minor project topics could also be aligned to be implemented/executed based on any of the 16 Centre of Excellence (CoE)/ 06 Center of Competence (CoC) domain. The details of these could be obtained by visiting the website https://rvce.edu.in/rvce-center-excellence
5. Minor project has to be implemented/executed in-house, using the resources available in the department/college/CoE/CoC.
6. Students have to note the periodic progress in the Minor Project Diary and report the work carried to their respective guides.
7. Students have to present the Minor project work to the departmental committee and only upon approval by the committee, the student can proceed to prepare and submit the hard copy of the final Minor project report.
8. The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be softbound in Ivory/White color for PG circuit Programs and Light Blue for Non-Circuit Programs.

Course Outcomes:

After going through this course the student will be able to:

CO1	:	Analyze the research gaps, formulate the problem definition, conceptualize the objectives and design solution to cater to specific problems.
CO2	:	Apply higher order thinking skills and develop skill competencies specific to program specialization to implement real world problems with professional ethical standards.
CO3	:	Demonstrate the skill and knowledge by applying appropriate tools and techniques specific to their domain.
CO4	:	Communicate, work in teams and demonstrate the learning through oral presentations and report writing.

Scheme of Continuous Internal Evaluation (CIE):

The evaluation committee shall consist of Guide, Professor, Associate Professor/Assistant Professor. The committee shall assess and evaluate the presentation and the progress reports.

The evaluation criteria shall be as per the rubrics given below:		
Reviews	**Activity**	**Weightage**
I	Approval of the selected topic, formulation of Problem Statement and Objectives along with Synopsis submission	10%
II	Demonstrate the skill and knowledge by applying appropriate tools/techniques to design solution specific to the problem.	30%
III	Demonstrates the work carried out through experimental results, analysis and testing. Exhibits writing and communication skills through presentations and report writing.	60%

Scheme for Semester End Evaluation (SEE):
The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner. Evaluation shall be done in batches, not exceeding 6 students per batch.

RUBRICS FOR SEMESTER END EXAMINATION

The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner.

Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	**20%**
2	Demonstration of Minor Project Work	**60%**
3	Viva voce	**20%**

SEMESTER: III						
Course Code	:	MBT434N	**INTERNSHIP**	CIE Marks	:	100
Credits L-T-P	:	0-0-6		SEE Marks	:	100
Hours/Week	:	12		SEE Duration	:	3 Hours

Guidelines

1. Students can opt for undergoing internship at the industry or research organizations like BEL, DRDO, ISRO, NAL, etc.
2. Students must submit letter from the industry/research organizations clearly specifying the candidate's name and the duration of the internship on the company letter head with authorized signature.
3. The duration of the internship shall be for a period of 6 weeks on full time basis after II semester final exams and before the commencement of III semester.
4. RVCE hosts around 16 Centre of Excellence (CoE) in various domains and around 06 Center of Competence (CoC). The details of these could be obtained by visiting the website https://rvce.edu.in/rvce-center-excellence
5. Students can approach the CoE/CoC for registering and working on relevant domain for training/internship at the CoE/CoC.
6. Internship must be related to the field of specialization of the respective PG program in which the student has enrolled.
7. Students undergoing internship training are advised to report their progress and submit periodic progress reports/diary to their respective guides.
8. Students have to present the internship activities carried out to the departmental committee and only upon approval by the committee, the student can proceed to prepare and submit the hard copy of the final internship report.
9. The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be softbound in Ivory/White color for PG circuit Programs and Light Blue for Non-Circuit Programs.

Course Outcomes:
After going through this course the student will be able to:

CO1	:	Explore the workplace, operating procedures of the department/company and its products, and other organizational concepts.
CO2	:	Learn and improve writing and communication skills, research and technology, work in a team, and develop leadership skills.
CO3	:	Apply higher order thinking skills - critical thinking, analysis, synthesis and evaluate complex problems to solve real world problems with professional ethical standards.
CO4	:	Develop and demonstrate skill competencies and knowledge specific to program specialization by applying appropriate tools and techniques.

Scheme of Continuous Internal Evaluation (CIE):
The evaluation committee shall consist of Guide, Professor, Associate Professor/Assistant Professor. The committee shall assess and evaluate the presentation and the progress reports.

The evaluation criteria shall be as per the rubrics given below:

Reviews	Activity	Weightage
I	Ability to comprehend the functioning/operating procedures of the Organization/Departments. Application of Engineering knowledge, Critical thinking and analysis to solve problems.	40%
II	Demonstrates skill competencies, Resource Management and Sustainability. Exhibits writing and communication skills through presentations and report writing.	60%

Scheme for Semester End Evaluation (SEE):
The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner. Evaluation shall be done in batches, not exceeding 6 students per batch.

RUBRICS FOR SEMESTER END EXAMINATION		
The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner.		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	**20%**
2	Demonstration of Internship Work	**60%**
3	Viva	**20%**

SEMESTER: IV						
Course Code	:	MBT341F1	**TRACTION ENGINEERING**	CIE Marks	:	NA
Credits L-T-P	:	2-0-0	*(Theory - NPTEL Course online)*	SEE Marks	:	100
Hours	:	16L	*Program Specific Courses (NPTEL-Elective) (Group-F)*	SEE Duration	:	3 Hours

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: Fundamentals of traction and traction elements
Week 2: Mechanics of wheel and characterization of terrain response
Week 3: Methods and parametric analysis of wheels (rigid and pneumatic)
Week 4: Methods and parametric analysis of track
Week 5: Measurements of performance parameters of tyre in a soil bin (laboratory)
Week 6: Effect of tyre parameters and operating parameters on tractive performance and selection of tyres
Week 7: Traction aids and cornering properties of tyre
Week 8: Steady state handling characteristics of tractor with tyres

Course duration: 8 Weeks
Course start Date: Jan 20,2025 (Tentative)
Course end date: March 14,2025
Probable Exam date: March 22,2025
Course Instructors: Prof. Hifjur Raheman, Department of Agricultural and Food Engineering, IIT Kharagpur

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
2. NPTEL is offering online certification courses through its portal -https://swayam.gov.in/nc_details/NPTEL
3. Enrollment to courses and exam registration can be done in ONLINE mode only. The link is available on NPTEL website http://nptel.ac.in/
4. Students need to enroll for the NPTEL course and clear the exam.
5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL.

SEMESTER: IV						
Course Code	:	MBT341F2	**FOOD MICROBIOLOGY FOR SAFE AND SUSTAINABLE FOOD SYSTEMS**	CIE Marks	:	NA
Credits L-T-P	:	2-0-0	*(Theory - NPTEL Course online)*	SEE Marks	:	100
Hours	:	16L	*Program Specific Courses (NPTEL-Elective) (Group-F)*	SEE Duration	:	3 Hours

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: Introduction to Food Microbiology
Week 2: Beneficial Microorganism in Food
Week 3: Contaminates of Food
Week 4: Microbial Growth
Week 5: Microbial Food Spoilage
Week 6: Diseases by Foodborne microbes
Week 7: Mechanism of Microorganism Control in Food
Week 8: Food Safety, Packing and Food Standard

Course duration: 8 Weeks
Course start Date: Jan 20,2025 (Tentative)
Course end date: March 14,2025
Probable Exam date: March 22,2025
Course Instructors: Prof. Prem Prakash Srivastav, Department of Agriculture and Food Engineering, IIT Kharagpur

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
2. NPTEL is offering online certification courses through its portal -https://swayam.gov.in/nc_details/NPTEL
3. Enrollment to courses and exam registration can be done in ONLINE mode only. The link is available on NPTEL website http://nptel.ac.in/
4. Students need to enroll for the NPTEL course and clear the exam.
5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL.

SEMESTER: IV						
Course Code	:	MBT341F3	**BIOINTERFACE ENGINEERING**	CIE Marks	:	NA
Credits L-T-P	:	2-0-0	*(Theory - NPTEL Course online)*	SEE Marks	:	100
Hours	:	16L	*Program Specific Courses (NPTEL-Elective) (Group-F)*	SEE Duration	:	3 Hours

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: Intermolecular Forces
Week 2: Adhesion and Wetting Phenomena
Week 3: Characterization of interfaces
Week 4: Protein-surface interactions
Week 5: Protein Aggregation
Week 6: Cell-surface interactions
Week 7: Surface modification and characterization
Week 8: Surface modification and characterization

Course duration: 8 Weeks
Course start Date: Jan 20,2025 (Tentative)
Course end date: March 14,2025
Probable Exam date: March 22,2025
Course Instructors: Prof. Lalit M Pandey, Department of Biosciences and Bioengineering, IIT Guwahati

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
2. NPTEL is offering online certification courses through its portal -https://swayam.gov.in/nc_details/NPTEL
3. Enrollment to courses and exam registration can be done in ONLINE mode only. The link is available on NPTEL website http://nptel.ac.in/
4. Students need to enroll for the NPTEL course and clear the exam.
5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL. Exam is conducted by NPTEL.

SEMESTER: IV						
Course Code	:	MBT341F4	**NANOTECHNOLOGY IN AGRICULTURE**	CIE Marks	:	NA
Credits L-T-P	:	2-0-0	*(Theory - NPTEL Course online)*	SEE Marks	:	100
Hours	:	16L	*Program Specific Courses (NPTEL-Elective)(Group-F)*	SEE Duration	:	3 Hours

This course is indicative only and it is subject to change based on the courses running at that time by NPTEL

Duration of the ONLINE Course - 8 Weeks

Week 1: History of agriculture and the role of chemicals in modern agriculture
Week 2: Overview of nanotechnology
Week 3: Application of nanotechnology in modern day agriculture practices I
Week 4: Application of nanotechnology in modern day agriculture practices II
Week 5: Application of nanotechnologies in animal production
Week 6: Nanotechnology and shelf life of agricultural and food products
Week 7: Nanotechnologies for water quality and availability
Week 8: Green nanotechnology and the role of good governance and policies for effective nanotechnology development

Course duration: 8 Weeks

Course start Date: Jan 20,2025 (Tentative)
Course end date: March 14,2025
Probable Exam date: March 22,2025

Course Instructors: Prof. Mainak Das, Department of Biological Sciences & Bioengineering, IIT Kanpur

GENERAL GUIDELINES

1. NPTEL is an acronym for National Programme on Technology Enhanced Learning which is an initiative by seven Indian Institutes of Technology (IIT Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and Indian Institute of Science (IISc) for creating course contents in engineering and science.
2. NPTEL is offering online certification courses through its portal -https://swayam.gov.in/nc_details/NPTEL
3. Enrollment to courses and exam registration can be done in ONLINE mode only. The link is available on NPTEL website http://nptel.ac.in/
4. Students need to enroll for the NPTEL course and clear the exam.
5. In case students fail to get the certificate, they need to enroll for the same course once again, in the subsequent NPTEL semester and clear the exam.
6. If the same course is not offered by NPTEL (i.e. if the same course is not re-run) in the subsequent semester by NPTEL, the students need to write letter seeking permission from the Counsellor, HoD and Dean Academics with further approval from BoS Committee to take alternative course from the list announced by NPTEL.
7. Exam is conducted by NPTEL.

SEMESTER: IV						
Course Code	:	MBT442P	**MAJOR PROJECT**	CIE Marks	:	100
Credits L-T-P	:	0-0-18		SEE Marks	:	100
Hours/Week	:	42		SEE Duration	:	3 Hours

Guidelines

1. Major Project is to be carried out for a duration of 18 weeks
2. Student have to implement the Major Project individually.
3. Students are required to select topics related to their PG Program Specialization after extensive Literature Survey and analyzing the Research gaps.
4. Students will be assigned to guides in accordance with the expertise of the faculty.
5. Major project topics could also be chosen to be implemented/executed based on any of the 16 Centre of Excellence (CoE)/ 06 Center of Competence (CoC) domain. The details of these could be obtained by visiting the website https://rvce.edu.in/rvce-center-excellence be implemented in Industry/Research organizations after providing the letter of approval.
6. Students can also implement Major Project, in-house using the resources available in the department/college/CoE/CoC.
7. Students have to adhere to the Project Presentation Schedule note the periodic progress in the Major Project Diary and report the work carried to their respective guides.
8. It is mandatory for the students to present/publish their project work in National/International Conferences/Journals
9. Students have to present the Major Project work to the departmental committee and only upon approval by the committee, the student can proceed to prepare and submit the hard copy of the final Major Project report.
10. Major Project report has to be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be softbound in Ivory/White color for PG circuit Programs and Light Blue for Non-Circuit Programs.

11. Course Outcomes:

12. After going through this course, the student will be able to:

CO1	:	Analyze the research gaps, formulate the problem definition, conceptualize the objectives and design solution to cater to specific problems.
CO2	:	Apply higher order thinking skills and develop skill competencies specific to program specialization to implement real world problems with professional ethical standards.
CO3	:	Demonstrate the skill and knowledge by applying appropriate tools and techniques specific to their domain.
CO4	:	Communicate, work in teams and demonstrate the learning through oral presentations and report writing.

Scheme of Continuous Internal Evaluation (CIE):

The evaluation committee shall consist of Guide, Professor, Associate Professor/Assistant Professor. The committee shall assess and evaluate the presentation and the progress reports.

The evaluation criteria shall be as per the rubrics given below:

Reviews	Activity	Weightage
I	Approval of the selected topic, formulation of Problem Statement and Objectives along with Synopsis submission	10%
II	Demonstrate the skill and knowledge by applying appropriate tools/techniques to design solution specific to the problem.	30%
III	Demonstrates the work carried out through experimental results, analysis and testing. Exhibits writing and communication skills through presentations, report writing and paper publication.	60%

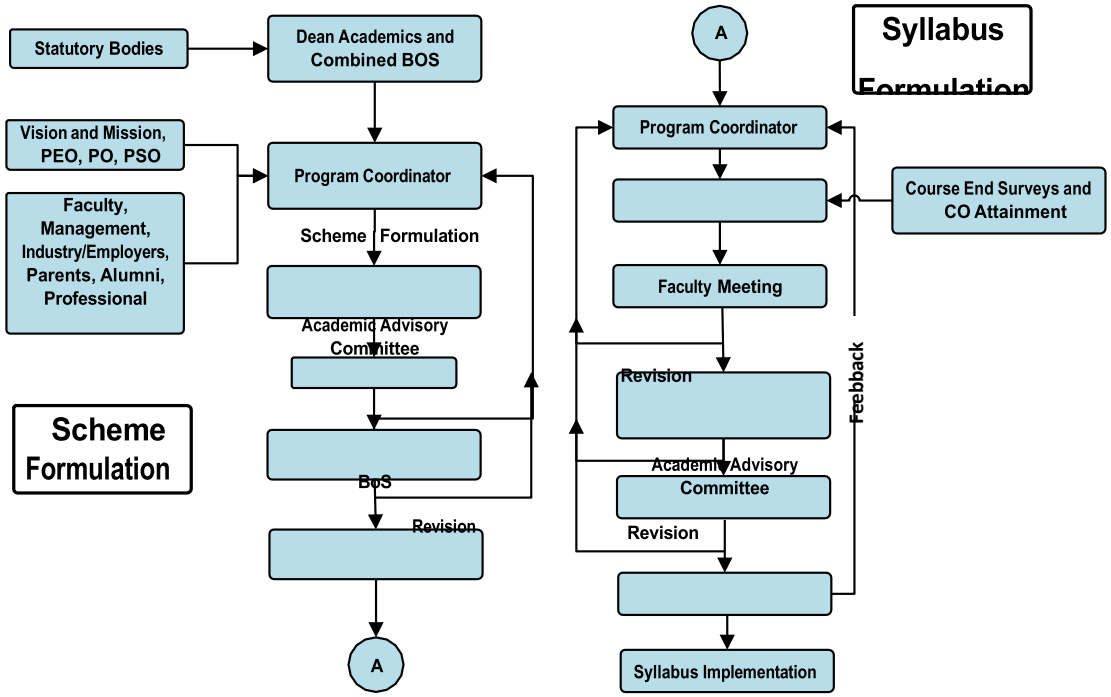
Scheme for Semester End Evaluation (SEE):
Major Project SEE evaluation shall be conducted in two stages. This is initiated after fulfilment of submission of Project Report and CIE marks.
Stage-1 Report Evaluation: Evaluation of Project Report shall be done by the Guide and an External examiner.
Stage-2 Project Viva-voce: Major Project Viva-voce examination is conducted after receipt of evaluation reports from Guide and External examiner.

RUBRICS FOR SEMESTER END EXAMINATION

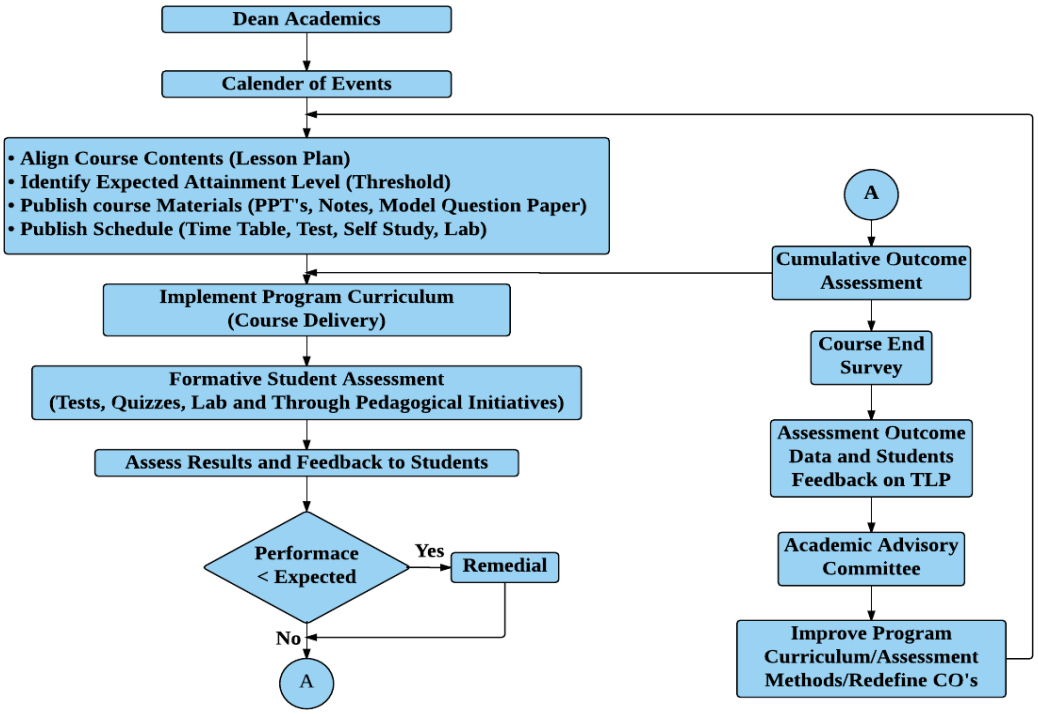
SEE procedure is as follows:

Report Evaluation	Internal Examiner: 100 Marks **(A)**	**Report Evaluation (A) + (B) = 200/2 = 100 (C)**
	External Examiner: 100 Marks **(B)**	
Viva-Voce	Jointly evaluated by Internal Guide & External Examiner	**100 (D)**
Total Marks = **(C+D)/2** = 200/2 =100		**100 Marks**

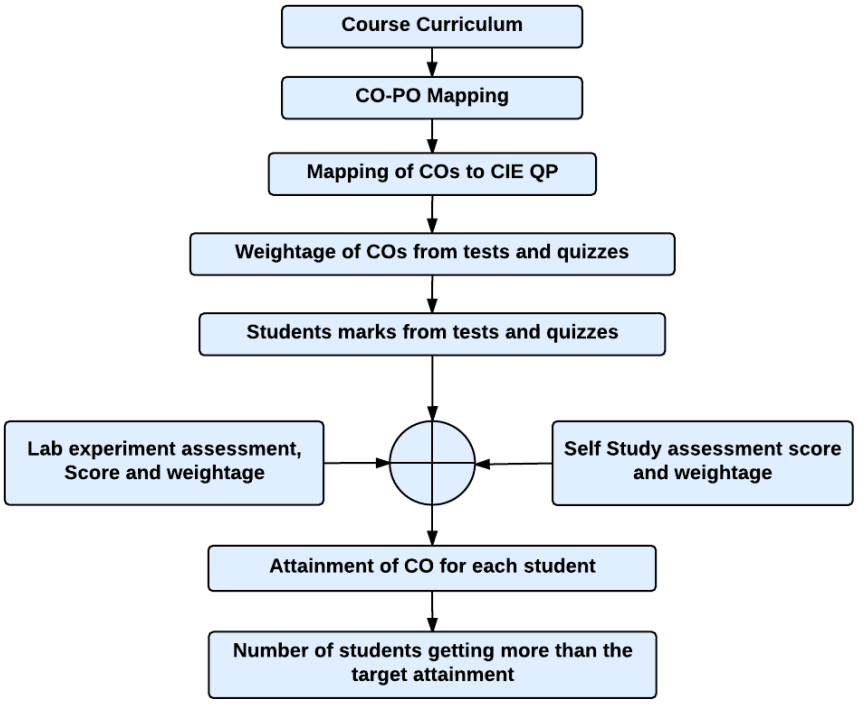
Curriculum Design Process



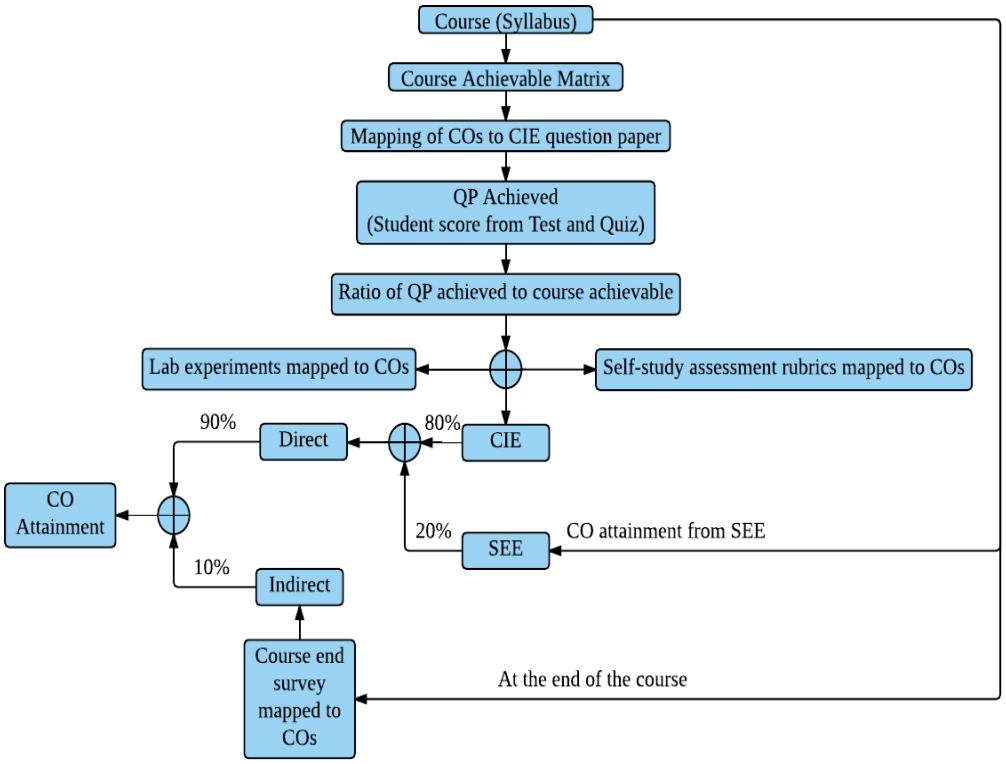
Academic Planning and Implementation



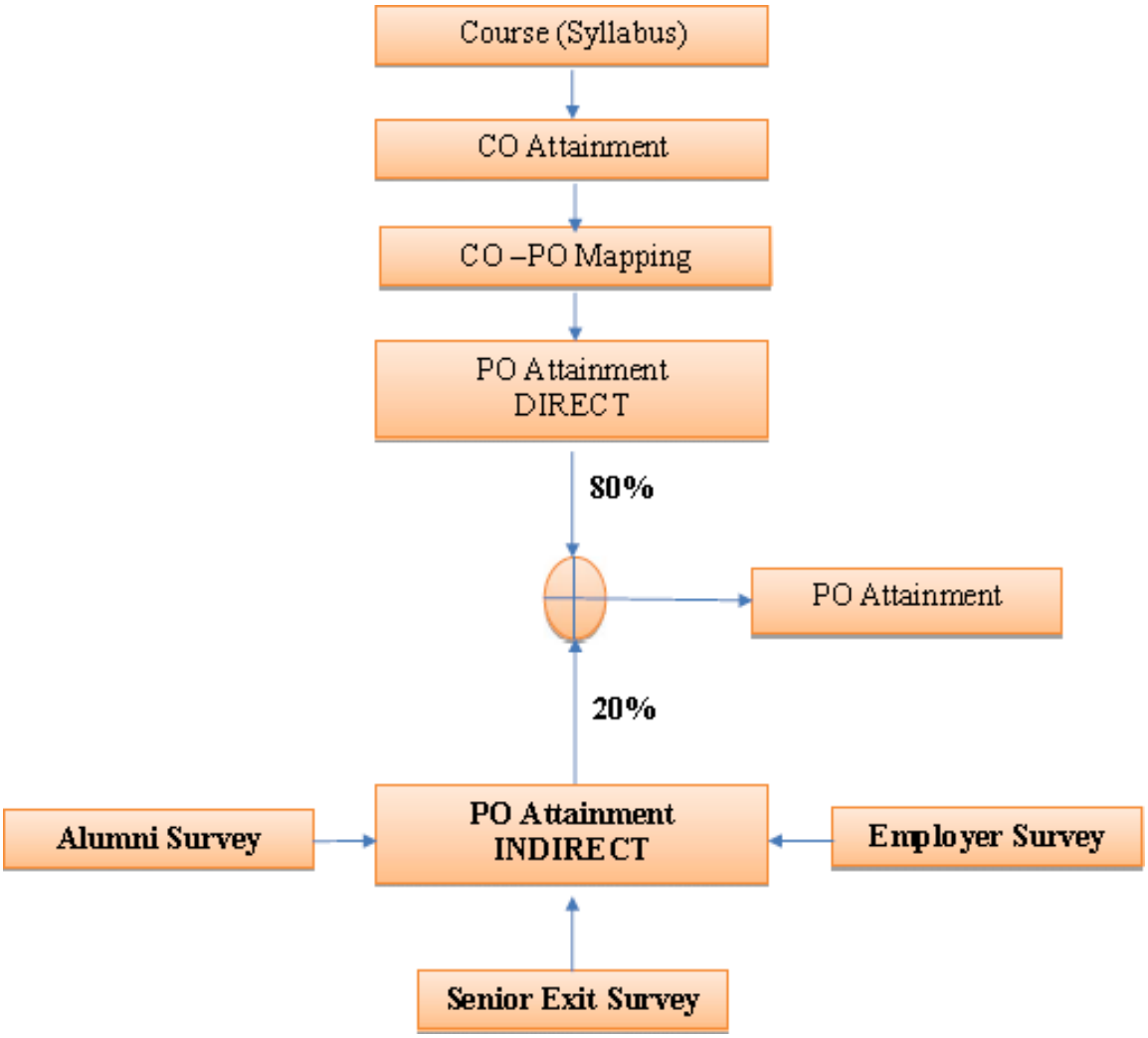
Process For Course Outcome Attainment



Final CO Attainment Process



Program Outcome Attainment Process



INNOVATIVE TEAMS OF RVCE

1. Ashwa Racing : Ashwa Mobility Foundation (AMF) is a student R&D platform that designs and fabricates Formula-themed race cars and future mobility solutions to tackle urban transportation problems.
2. Astra Robotics Team : Involved in the design, fabrication, and building of application-specific robots.
3. Coding Club : To facilitate students in acquiring the skills, confidence, and opportunities to change their world using coding. The club aims to help students become successful in GSoC, ACM-ICPC, and other recognized coding competitions.
4. Entrepreneurship Development Cell : E-Cell is a student-run body that aims to promote entrepreneurship by conducting workshops, speaker sessions, and discussions on business and its aspects. The organization possesses a mentor board to help startups grow.
5. Frequency Club Team : This team contributes to both software and hardware domains, mainly focusing on Artificial Intelligence, Machine Learning, and its advances.
6. Team Garuda : Design and development of a supermileage urban concept electric car. Indigenous development of E-mobility products.
7. Team Jatayu : Aims to build a low-cost Unmanned Aerial Vehicle capable of autonomous navigation, obstacle avoidance, object detection, localization, classification, and air drop of a package of optimum weight.
8. Solar Car : Aims to build a roadworthy solar electric vehicle to contribute to a green and sustainable environment.
9. Team Antariksh : A Space Technology Student Club whose goal is to understand, disseminate, and apply engineering skills for innovation in the field of Space technology, including the development of operational rockets of various altitude platforms.
10. Team Chimera : Building a Formula Electric Car through research and development in E-Mobility.Electrifying Formula Racing.
11. Helios Racing Team : Involved in the design, manufacturing, and testing of All-Terrain Vehicles and other supportive tasks for the functioning of the team. Participating in BAJA competitions organized by SAE in India and the USA.
12. Team Hydra : Developing autonomous underwater vehicles for various real-world applications such as water purification, solid waste detection and disposal, etc.
13. Team Krushi : Aims to develop low-cost equipment to help farmers in cultivating and harvesting. Uses new technology applications to reduce labor time and cost for farmers. Aims at developing implements for tractors.
14. Team Vyoma : Design, fabrication, and testing of radio-controlled aircraft and research on various types of unmanned aerial vehicles.
15. Team Dhruva : Organizing activities like quizzes based on astronomy, stargazing, and telescope handling sessions. Construction of a standard observatory and working on small projects with organizations like ICTS, IIA, ARIES, etc.
16. Ham Club : To popularize Amateur Radio as a hobby among students, alongside exploring technical innovations in the communications domain. Intended to provide human capital for service to the nation during times of natural calamities.

Cultural Activity Teams

AALAP (Music club) DEBSOC (Debating society) CARV (Dramatics club) FOOTPRINTS (Dance club) QUIZCORP (Quizzing society)

ROTARACT (Social welfare club)
RAAG (Youth club)

NSS of RVCE

NCC of RVCE

VISION

Leadership in Quality Technical Education, Interdisciplinary Research & Innovation, with a Focus on Sustainable and Inclusive Technology

MISSION

- To deliver outcome based Quality education, emphasizing on experientiallearning with the state of the art infrastructure.
- To create a conducive environment for interdisciplinary research and innovation.
- To develop professionals through holistic education focusing on individual growth, discipline, integrity, ethics and social sensitivity.
- To nurture industry-institution collaboration leading to competency enhancement and entrepreneurship.
- To focus on technologies that are sustainable and inclusive, benefiting all sections of the society.

QUALITY POLICY

Achieving Excellence in Technical Education, Research and Consulting through an Outcome Based Curriculum focusing on Continuous Improvement and Innovation by Benchmarking against the global Best Practices.

CORE VALUES

Professionalism, Commitment, Integrity, Team Work, Innovation