RV Educational Institutions ®
RV College of Engineering ®

Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi

Approved by AICTE, New Delhi

Go, change the world

SCHEME & SYLLABUS
THIRD YEAR B.E. PROGRAMS

BIOTECHNOLOGY

BACHELOR OF ENGINEERING (B.E.)
2021 SCHEME

ACADEMIC YEAR 2023-24

DEPARTMENT VISION

A Premier Department in Biotechnology Education, Research and Innovation with a Focus on Sustainable Technologies for the Benefit of Society and Environment.

DEPARTMENT MISSION

- Create state-of-the-art infrastructure for research and training in Biotechnology.
- Develop graduates who are ethical and socially concerned.
- Promoting collaboration with academia, industries and research organizations at national and international level.
- Contribute to socioeconomic development through sustainable and inclusive technologies

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Have a strong foundation in scientific and engineering fundamentals that prepare them for a successful career in Biotechnology and allied fields

PEO2: Function at a technically competent level in formulating and solving problems in Biotechnology

PEO3: Organize and utilize the knowledge to develop Biological processes and gene manipulation techniques

PEO4: Exhibit professionalism, ethical attitude, oral and written communication skills, team work and develop an outlook for lifelong learning

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO	Description
PSO1	Gain knowledge in Basic sciences, Mathematics and Biology to understand the Engineering problems related to Biotechnology and Bioinformatics.
PSO2	Develop the skills in the area of Biotechnology, Chemical Engineering and Informatics to solve complex Biological problems.
PSO3	Acquire technical knowledge to design, analyse, optimize and scale up Bio processes to develop value added products.
PSO4	Develop intellectual, personal and professional abilities through experiential learning and interdisciplinary projects

ABBREVIATIONS

Sl. No.	Abbreviation	Meaning
1.	VTU	Visvesvaraya Technological University
2.	BS	Basic Sciences
3.	CIE	Continuous Internal Evaluation
4.	SEE	Semester End Examination
5.	PE	Professional Core Elective
6.	GE	Global Elective
7.	HSS	Humanities and Social Sciences
8.	PY	Physics
9.	CY	Chemistry
10.	MA	Mathematics
11.	AS	Aerospace Engineering
12.	AI & ML	Artificial Intelligence & Machine Learning
13.	BT	Biotechnology
14.	CH	Chemical Engineering
15.	CS	Computer Science & Engineering
16.	CV	Civil Engineering
17.	EC	Electronics & Communication Engineering
18.	EE	Electrical & Electronics Engineering
19.	EI	Electronics & Instrumentation Engineering
20.	ET	Electronics & Telecommunication Engineering
21.	IM	Industrial Engineering & Management
22.	IS	Information Science & Engineering
23.	ME	Mechanical Engineering

INDEX

Bachelor of Engineering in
BIOTECHNOLOGY

V SEMESTER													
Sl. No.	**Course Code**	**Course Title**	**Credit Allocation**				**BoS**	**Category**	**CIE Duration (H)**	**Max Marks CIE**		**SEE Duration (H)**	**Max Marks SEE**	
			L	**T**	**P**	**Total**				**Theory**	**Lab**		**Theory**	**Lab**
1	21HS51B	Principles of Management & Economics	3	0	0	**3**	HSS	Theory	1.5	**100**	****	**3**	**100**	****
2	21BT52	Bioinformatics	3	0	1	**4**	BT	Theory+Lab	1.5	**100**	**50**	**3**	**100**	**50**
3	21BT53	Genetic Engineering	3	0	1	**4**	BT	Theory+Lab	1.5	**100**	**50**	**3**	**100**	**50**
4	21BT54	Microbial Biotechnology	3	0	1	**4**	BT	Theory+Lab	1.5	**100**	**50**	**3**	**100**	**50**
5	21BT55BX	Professional Core Elective-I (Group B)	3	0	0	**3**	BT	Theory	1.5	**100**	****	**3**	**100**	****
6	21BT56CX	Professional Core Elective-II (Group C)	2	0	0	**2**	BT	NPTEL	1.5	**50**	****	**2**	**50**	****
7	21BT157	Summer Internship - II	0	0	2	**2**	BT	Internship	1	****	**50**	**2**	****	**50**
Total						**22**								

GROUP-B		
Sl. No.	**Course Code**	**Course Title**
1	21BT55B1	Pharmaceutical Biotechnology
2	21BT55B2	Agricultural Biotechnology
3	21BT55B3	Plant Utilities And Biosafety In India
4	21BT55B4	Systems Biology
5	21BT55B5	Enzyme Technology

GROUP-C		
Sl. No.	**Course Code**	**Course Title**
1	21BT56C1	Introductory mathematical methods for biologists
2	21BT56C2	Bioengineering: an interface with biology and medicine
3	21BT56C3	Biointerface engineering
4	21BT56C4	Data analysis for Biologists
5	21BT56C5	Nano technology in agriculture

Bachelor of Engineering in
BIOTECHNOLOGY

VI SEMESTER

Sl. No.	Course Code	Course Title	Credit Allocation				BoS	Category	CIE Duration (H)	Max Marks CIE		SEE Duration (H)	Max Marks SEE	
			L	T	P	Total				Theory	Lab		Theory	Lab
1	21HS61A	Intellectual Property Rights & Entrepreneurship	3	0	0	**3**	HSS	Theory	1.5	**100**	****	**3**	**100**	****
2	21BT62	Reaction Engineering	3	0	1	**4**	BT	Theory+Lab	1.5	**100**	**50**	**3**	**100**	**50**
3	21BT63	Plant & Animal Biotechnology	3	0	1	**4**	BT	Theory+Lab	1.5	**100**	**50**	**3**	**100**	**50**
4	21BT64DX	Professional Core Elective – III (Group D)	3	0	0	**3**	BT	Theory	1.5	**100**	****	**3**	**100**	****
5	21BT65EX	Professional Core Elective (Cluster Elective –Group E) (2 Courses under each Program)	3	0	0	**3**	BT	Theory	1	**100**	****	**3**	**100**	****
6	21IE6FX	Institutional Electives - I (Group F)	3	0	0	**3**	Respective BOS	Theory	1.5	**100**	****	**3**	**100**	****
						20								

GROUP-D		
Sl. No.	**Course Code**	**Course Title**
1	21BT64D1	Biomedical Instrumentation
2	21BT64D2	Food & Dairy Biotechnology
3	21BT64D3	Fermentation Technology
4	21BT64D4	Programming In Biotechnology
5	21BT64D5	Equipment Design And Drawing

GROUP-E		
Sl. No.	**Course Code**	**Course Title**
1	21BT65E1	Nanobiotechnology
2	21BT65E2	Nature Impelled Technologies
3	21CH65E1	Bioenergy Technology
4	21CH65E2	Hydrogen Technology
5	21CV65E1	Disaster Management
6	21CV65E2	Solid Waste Management

GROUP-F			
Sl. No.	**Course Code**	**BoS**	**Course Title**
1	21IE6F1	CH	Industrial Safety and Risk Management
2	21IE6F2	EE	Renewable Energy Systems
3	21IE6F3	IM	Systems Engineering
4	21IE6F4	ME/EC	Mechatronics
5	21IE6F5	MA	Mathematical Modelling
6	21IE6F6	ME	Industry 4.0 – Smart Manufacturing for The Future
7	21IE6F7	HSS	Industrial Psychology for Engineers
8	21IE6F8	IM	Elements of Financial Management
9	21IE6F9	HSS	Universal Human Values-II
10	21IE6F10	HSS	Human Machine Interface (Industry Offered Elective)

Semester: V/VI						
PRINCIPLES OF MANAGEMENT & ECONOMICS (Common to All Programs) (Theory)						
Course Code	**:**	**21HS51B**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45Hrs**		**SEE Duration**	**:**	**3Hours**

Unit-I	**06 Hrs**
Introduction to Management: Management Functions – POSDCORB – an overview, Management levels & Skills, Management History - **Classical Approach:** Scientific Management, Administrative Theory, **Quantitative Approach:** Operations Research, **Behavioral Approach:** Hawthorne Studies, **Contemporary Approach:** Systems Theory, Contingency Theory. **Caselets / Case studies**	
Unit – II	**10 Hrs**
Foundations of Planning: Types of Goals & Plans, Approaches to Setting Goals & Plans, Strategic Management Process, Corporate strategies – types of corporate strategies, BCG matrix, Competitive Strategies – Porters Five force Model, types of Competitive Strategies. **Caselets / Case studies Organizational Structure & Design:** Overview of Designing Organizational Structure - Work Specialization, Departmentalization, Chain of Command, Span of Control, Centralization & Decentralization, Formalization, Mechanistic & Organic Structures. **Caselets / Case studies**	
Unit –III	**10 Hrs**
Motivation: Early Theories of Motivation - Maslow's Hierarchy of Needs Theory, McGregor's Theory X & Theory Y, Herzberg's Two Factor Theory. Contemporary Theories of Motivation: Adam's Equity theory, Vroom's Expectancy Theory. **Caselets / Case studies** **Leadership:** Behavioral Theories: Blake & Mouton's Managerial Grid, Contingency Theories of Leadership: Hersey & Blanchard's Situational Leadership, Contemporary Views of Leadership: Transactional & Transformational Leadership. **Caselets / Case studies**	
Unit –IV	**10 Hrs**
Introduction to Economics: Microeconomics and Macroeconomics, Circular flow model of economics, An Overview of Economic Systems. **Macroeconomic models**- The classical growth theory, Keynesian cross model, IS-LM-model, The AS-AD model, The complete Keynesian model, The neo-classical synthesis. National Budgeting process in India. **Macroeconomic Indicators:** Prices and inflation, Consumer Price Index, Exchange rate, Labor Market, Money and banks, Interest rate. Gross Domestic product (GDP) - components of GDP, Measures of GDP: Outcome Method, Income method and Expenditure method, Numericals on GDP Calculations.	
Unit –V	**09 Hrs**
Essentials of Microeconomics: Demand, Supply, and Equilibrium in Markets for Goods and Services, Price Elasticity of Demand and Price Elasticity of Supply, Elasticity and Pricing, Numericals on determining price elasticity of demand and supply. Changes in Income and Prices Affecting Consumption Choices, Monopolistic Competition, Oligopoly.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Elucidate the principles of management theory & recognize the characteristics of an organization.
CO2	Demonstrate the importance of key performance areas in strategic management and design appropriate organizational structures and possess an ability to conceive various organizational dynamics.
CO3	Compare and contrast early and contemporary theories of motivation and select and implement the right leadership practices in organizations that would enable systems orientation.
CO4	Demonstrate an understanding on the usage and application of basic economic principles.
CO5	Appreciate the various measures of macro-economic performance and interpret the prevailing economic health of the nation.

Reference Books	
1.	Management, Stephen Robbins, Mary Coulter & NeharikaVohra, 15th Edition, 2021, Pearson Education Publications, ISBN: 13: 978-0-13-558185-8
2.	Management, James Stoner, Edward Freeman & Daniel Gilbert Jr, 6th Edition, 2009, PHI, ISBN: 81-203-0981-2.
3.	Principles of Microeconomics, Steven A. Greenlaw, David Shapiro, 2nd Edition, 2017, ISBN:978-1-947172-34-0
4.	Macroeconomics: Theory and Policy, Dwivedi D.N, 5th Edition, 2021, McGraw Hill Education; ISBN : 9789353163334

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	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. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**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.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: V

BIOINFORMATICS
Category: Professional Core Course
(Theory and Practice)

Course Code	**:**	**21BT52**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**3:0:1**		**SEE**	**:**	**100 +50 Marks**
Total Hours	**:**	**40L+30P**		**SEE Duration**	**:**	**3 Hours**

Unit-I — **09 Hrs**

Molecular Sequencing and Bioinformatics:

Introduction to Bioinformatics - Scope, Applications. DNA sequencing; Methods – Basic and Next Generation Sequencing methods - Maxam-Gilbert Method, Sanger Dideoxy method, Fluorescence method, shot-gun approach and Microarray based sequencing. Next Generation Sequencing (NGS) and NGS Experimental Work Flow. NGS Platforms - Illumina Reverse Dye-Terminator, Ion Torrent Semiconductor sequencing, Pacific Biosciences Single Molecule Real-Time Sequencing and ONT's MinION sequencing.

Unit – II — **08 Hrs**

Biological Databases:

Introduction – types; Nucleic acid Sequence databases, Protein Sequence Databases, Structural Databases, Special Databases – OMIM, Genome Databases. NGS databases – Zenodo, SRA, ENA,SRA and GEO. Accessing and Retrieval of NGS Data - SRA toolkit and Aspera connect. Sequence Analysis – Introduction, Overview of an Algorithms behind Sequence Analysis.

Unit –III — **08 Hrs**

Algorithms and Sequence analysis:

Scoring matrices– BLOSSUM and PAM. Algorithms and Sequence analysis; Dynamic Programming Algorithms – Needleman and Wunch & Smith and Waterman, BLAST, FASTA, and Exon Chaining. Phylogenetic analysis; Multiple Sequence Alignment, Clustering Algorithms – UPGMA and NJ and Tree evaluation. Genome Assembly and Genome Mapping Algorithms – GoldRush and BWT. Machine Learning Algorithms for Gene prediction and Prediction of Secondary structure of Protein.

Unit –IV — **08 Hrs**

Next Generation Sequencing 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. Linkage mapping, and Genome Mapping with NGS.

Unit –V — **07 Hrs**

Molecular modelling and Drug designing:

Introduction to Molecular Modelling and Simulation; brief introduction to protein structure hierarchy. Modelling applications – prediction of secondary structure of Protein and RNA. Docking Process – Protein preparation, ligand building, Prediction of Binding pockets, Scoring, Next Generation Sequencing in Cancer Research.

Laboratory Experiments:

1. Retrieval of Sequence, Structure and NGS Data from GenBank, PDB, Zenodo, SRA and ENA.
2. Sequence alignment – Global, Local and Multiple Sequence alignment.
3. Restriction mapping and Primer Designing.
4. Protein modelling using MODELLER.
5. Design and Execute Cloud Based Workflow for Functional annotation of protein sequences.
6. Design, Implement and Execute Python based Workflow for Phylogenetic Analysis.
7. Design, Implement and Execute Python based Workflow for Genome Assembly.
8. Design, Implement and Execute Python based Workflow for Exome Analysis.
9. Design, Implement and Execute Python based Workflow for Metagenomic Analysis.

10. Design, Implement and Execute Python based Workflow for Meta Transcriptomic Analysis. 11. Design, Implement and Execute Python based Workflow for Genome Annotation. 12. Design and Execution of Workflow of High Throughput Virtual Screening on Cloud Platform. 13. Design and Execute Python based Workflow of Variant Calling for Human Genome Data on Cloud Platform

Course Outcomes: After completing the course, the students will be able to	
CO1	Demonstrate the knowledge of Data retrieval Sequence, Structure of Molecules, and Metabolic Networks, its analysis and its interpretation.
CO2	Analyse the Computational algorithms to study Biological data of gene, genomes, protein, RNA and metabolic networks to identify patterns and relationships.
CO3	Apply the Computational algorithms for Computational Modelling and simulations in the field of drug design, diagnosis, Genomics and Proteomics.
CO4	Implementation of Python based Workflows for Genomics, Proteomics and structural Bioinformatics.

Reference Books	
1	Xinkun Wang, Next-Generation Sequencing Data Analysis, CRC Press 2016, 9781482217896.
2	Martti Tapani Tammi, Lloyd Low, Bioinformatics - A Practical Handbook of Next Generation Sequencing and Its Applications, World Scientific 2017, ISBN: 9789813144743.
3	Ka-Lok Ng, Jeffrey J. P. Tsai, Computational Methods With Applications In Bioinformatics Analysis, World Scientific Publishing Company 2017, ISBN: 9789813207998.
4	Outi Salo-Ahen, Rebecca Wade, Molecular Modeling in Drug Design, MDPI AG 2019, ISBN: 9783038976141.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY AND PRACTICE)		
#	**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 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**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks**. THE FINAL MARKS WILL BE 50 MARKS**	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: V						
GENETIC ENGINEERING **Category: Professional Core Course** **(Theory and Practice)**						
Course Code	**:**	**21BT53**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**3:0:1**		**SEE**	**:**	**100+50 Marks**
Total Hours	**:**	**39L+30P**		**SEE Duration**	**:**	**3 hours**

Unit-I	**07Hrs**
Introduction to Genetic Engineering: Basics of Genetic Engineering**,** Isolation and purification of DNA (Plasmid DNA, genomic DNA and RNA (bacterial, plants and animals). Vectors used for gene cloning. M**olecular tools for gene cloning:** Restriction and Modification systems. **Cloning Techniques**: Ligase dependent and Ligase independent cloning.	
Unit – II	**08 Hrs**
Gene transfer techniques: Physical, chemical and biological methods, Competent cells: Chemical and Electro-competent methods. Introduction of DNA into host cells. Screening and characterization of transformants; Selectable marker genes, reporter genes. Expression of recombinant proteins using bacterial, animal and plant vectors and their purification. Transformation/ transfection in plants and animals.	
Unit –III	**08Hrs**
Methods of nucleic acid/ protein detection; Polymerase chain reaction (PCR) - techniques and requirements, types of PCR, applications. Blotting techniques (Southern, Northern and Western), Radioactive and non-radioactive labelling of nucleic acids. High Throughput Screening (HTS) mode of hybridization: Microarray technique. **Construction of genomic and cDNA libraries:** Screening of DNA libraries for clone identification. Characterization of clones.	
Unit –IV	**08Hrs**
DNA-Protein interaction studies: **DNA-Protein interactions:** Electrophoretic Mobility Shift Assay (EMSA), Chromatin Immunoprecipitation (ChiP), DNA foot printing, Yeast One Hybrid, Surface Plasmon Resonance (SPR), Fluorescence Resonance Energy Transfer (FRET). **Protein- Protein Interaction Studies:** Yeast two hybrid, Co-Immunoprecipitation, (Co-IP) Bimolecular Fluorescence Complementation (BiFC).	
Unit –V	**08Hrs**
Applications of Genetic Engineering: Engineering microbes for the production of antibiotics, enzymes, insulin and monoclonal antibodies. Transgenic technology for plant and animal improvement: Over expression and knock out/ knock down studies, Bio pharming- Animals and plants as bioreactors for recombinant proteins. Case studies: Golden rice, BT Cotton. GMOs with Increase meat and milk production. Knockout mice and mice model for human genetic disorder. **Applications of Genome-Editing Technologies:** Case studies; Soybean, disease resistance and higher meat quality cattle.	

LABORATORY EXPERIMENTS

1 Isolation of plasmid DNA from gram positive and gram negative Bacteria
2. Isolation of genomic DNA (plant/ animal/ microbial sources)
3. Extraction of total RNA from *E.coli* cells
4. Agarose Gel Electrophoresis and quantification of nucleic acids
5. Restriction digestion of plasmid (with *EcoRI, HindIII* and *BamHI*) / genomic DNA
6. Reverse transcriptase - PCR reaction
7. Preparation of competent cells (*E.coli / Agrobacterium*)
8. Genetic transformation of *E.coli*
9. Screening techniques to select recombinants
10. Polymerase Chain Reaction (PCR) and design of primers
11. Isolation and Separation of Proteins - SDS-PAGE
12.Self-study/open ended experiment: Gene cloning: Cloning of gene fragment into a cloning vector

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the basic concepts of genetic engineering for augmentation of traits
CO2	Apply and comprehend the principles of gene manipulation, expression and interaction of genes and proteins.
CO3	Evaluate the screening and interaction studies using classical/conventional and high through put methods.
CO4	Design the strategies for gene cloning and gene editing

Reference Books	
1	Desmond S. T. Nicholl. An Introduction to Genetic Engineering. Cambridge University Press. 4th Edition, 2023.ISBN: 9781009180610.
2	T.A.Brown; Gene Cloning and DNA Analysis – An Introduction; Wiley-Blackwell Science; 7th edn;2018; ISBN: 9781405181730.
3	B.R. Glick, J.J.Pasternak and C.L Patten; Molecular Biotechnology – Principles and applications of recombinant DNA; ASM Press; 6th Edition; 2017; ISBN: 9781555814984.
4	Andy B. Primrose and Richard Twyman. Principles of Gene Manipulation and Genomics. Blackwell Publisher. 7th Edition. 2018.ISBN: 1405135441.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY AND PRACTICE)		
#	**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 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**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks**. THE FINAL MARKS WILL BE 50 MARKS**	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Q.NO.	CONTENTS	MARKS
1	Write Up	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: V

MICROBIAL BIOTECHNOLOGY
Category: Professional Core Course
(Theory and Practice)

Course Code	**:**	**21BT54**		**CIE**	**:**	**100+50 Marks**
Credits: L: T:P	**:**	**3:0:1**		**SEE**	**:**	**100+50 Marks**
Total Hours	**:**	**39L+30P**		**SEE Duration**	**:**	**3 Hours**

Unit-I — **09Hrs**

Introduction to Microbial Biotechnology: Scope and Applications of Microbial Biotechnology in Human Therapeutics, Environment, Agriculture, Food Technology, Bio reporters and Organic Chemistry. Microbial Production flow sheet for Enzymes, Microbial Metabolites and recombinant products. Isolation of industrially important microorganisms, preservation techniques of microbes, Fermentation Purification protocols for antibiotics and Metabolites from Fermentation Broth.

Unit – II — **08Hrs**

Microbial Production of Proteins and Enzymes: Production of therapeutic agents Pharmaceuticals (engineering human growth hormone), production of antibodies in *E coli.*, Production of attenuated vaccines (for cholera). Microbial insecticides- Cry (Bt) proteins, Enzymes-Alginate lyase and restriction endonucleases. Case study: Development of HIV Vaccine.

Unit –III — **08Hrs**

Microbial Production in Beverage and Food industry: Single cell protein production (SCP eg. Yeast)Beverages-Beer and wine. Acids- Citric and lactic acid. Enzymes- Amylase, Lipase. Biopolymers (Xanthan gum). Fermented foods (yoghurt and cheese). Cultivation of Mushrooms.

Unit –IV — **07 Hrs**

Microbial Production of Primary and Secondary Metabolites: Amino acids (glutamic acid and lysine), vitamins (B12, riboflavin and carotenoids), Antibiotics (β lactams, aminoglycosides, macrolides and tetracycline's) Improving antibiotic production.

Unit –V — **07Hrs**

Microbes in Environmental Biotechnology: Degradative capabilities of microorganisms, Degradation of xenobiotics, Genetic engineering of biodegradative pathways (Manipulation by transfer of plasmids and by gene alteration), Microorganisms in mineral recovery and removal of metals from aqueous effluent, Production of Biofuels (ethanol, methane and hydrogen).

LAB EXPERIMENTS

1) Wine production and estimation of alcohol content.
2) Preparation of baker's yeast from molasses.
3) Cultivation of algae (Spirulina).
4) Production and estimation of citric acid.
5) Fungal amylase production and assay of amylase activity.
6) Production of ethanol by immobilized cells.
7) Determination of order and rate constant in batch reactor.
8) Production of Protease from Bacteria.
9) Residence time distribution studies in plug flow reactor.
10) Residence time distribution studies in continuous stirred tank reactor.

ab

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember the basic principles to identify and produce compounds from microbial culture usingbioreactor.
CO2:	Understand the genetics and biosynthetic pathways of microbes for sustainable solutions.
CO3:	Create and evaluate genetically modified microorganisms for production of primary, secondary and recombinant metabolites.
CO4:	Apply methodology for production and extraction of products from microbial cultures under controlled conditions.

Reference Books	
1	Glazer, A. N. and H. Nikaido; Microbial Biotechnology; Fundamentals of Applied Microbiology. Cambridge University Press; 2 Editions, 2013.ISBN-13: 978-0521842105.
2	Arumugam N, A Mani, Dulsy Fatima, V Kumaresan, A M Selvaraj, L M Narayanan. Microbial Biotechnology. Saras Publication., First Edition. 2007, ISBN-13: 978-8189941260.
3	Rajesh Arora., Microbial Biotechnology: Energy and Environment. CAB International., 2012. ISBN: 978-1845939564.
4	Glick, B.R. J.J.Pasternak and C.L Patten; Molecular Biotechnology – Principles and applications of recombinant DNA; ASM Press; 4th Edn; 2016; ISBN: 978155581498.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY AND PRACTICE)		
#	**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 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**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks**. THE FINAL MARKS WILL BE 50 MARKS**	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: V						
PHARMACEUTICAL BIOTECHNOLOGY **Category: Professional Core Elective (Group B)** **(Theory)**						
Course Code	**:**	**21BT55B1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**08 Hrs**
INTRODUCTION: Current status and prospects for the Indian and global pharmaceutical industry. Drug development – Pre-formulation: structure determination, analytical development, salt form, chemical stability, physical-chemical properties, chiral properties, biopharmaceutical properties and excipient stability. Types of formulation: Liquids, semi-solids, solids and novel forms. Packaging and labeling. Clinical trials and quality assurance, Regulatory authority. Origin & development of the pharmacopoeia – IP/BP/USP, Introduction to monograph, parts of monograph. Introduction to biopharmaceutics	
Unit – II	**08 Hrs**
Facility design, unit operations and manufacturing: Structure Activity Relationship – QSARs and QSPRs, QSAR Methodology, Various Descriptors used in QSARs. Material flows considered, Floors, walls, and ceilings, Temperature and humidity controls, Air control, HEPA, Schedule M, Schedule Y layout setup, factory site, factory buildings, operation areas, facilities, GMP in solid dosage forms, liquids, parenteral. Scale-up considerations Large scale manufacturing of monophasic and biphasic liquids, semisolids and solids. 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.	
Unit –III	**08 Hrs**
Mechanisms of drug absorption through GIT, factors influencing drug absorption though GIT, absorption of drug from Non-per oral extra-vascular routes Drug metabolism, metabolic pathways, factors affecting metabolism, renal excretion of drugs, factors affecting renal excretion of drugs, renal clearance, Non- renal routes of drug excretion of drugs. Introduction to Pharmacokinetics, Pharmacokinetic models, One compartment open modelIntravenous Bolus Injection – Intravenous infusion - Extra vascular administrations. Determination of pharmacokinetics parameters and their significance - Absorption Rate Constant (ka), Elimination Rate Constant (K) & Elimination Hal- life (t½), AUC, Cmax, and tmax. Apparent Volume of Distribution (Vd) & Renal Clearance (Q).	
Unit –IV	**08 Hrs**
Pharmaceutical products and their action: Non-steroidal contraceptives, vitamins, gamma globulins, clinical dextran and absorbable haemostats. Nutraceuticals: Antioxidants, flavanoids, carotenoids, cholesterol lowering chemicals, nutritional importance and their functions, nutritional status evaluation Antihistaminic including anti-ulcer drugs, emetics, antiemetics, Non-steroidal anti-inflammatory agents, antipyretics Anti-osteoporotic drugs.	
Unit –V	**08 Hrs**
Drugs and their sites of action: Drugs acting on the central nervous system, cardiovascular system, blood and blood-forming agents, diuretics, gastrointestinal system and respiratory system. Drugs acting on hormonal system (a) Ant diabetic agents (b) Steriod hormones-adrenocorticoids, antiinflamatory steroids (c) Sex steroids and antagonists, oral contraceptive, anabolic steroids (d) Thyroid and ant thyroid agents (e) Drugs acting on calcium homeostatic, iron preparation	

Course Outcomes: After completing the course, the students will be able to	
CO1	Conceptualize the role of pharmaceutical products and their significance in modern society
CO2	Exercise better professionalism by incorporating manufacturing of pharmaceutical products and their uses
CO3	Describe types of diseases and their impact on human lives
CO4	Explain relationship between sprawling human population and related diseases

Reference Books	
1	Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications by Oliver Kayser, Heribert Warzecha, John Wiley & Sons, 2021, ISBN: 352765125X, 9783527651252
2	Goodman and Gilman's Manual of Pharmacology and Therapeutics by Laurence L. Brunton, Randa Hilal-Dandan. McGraw Hill Professional, 2022. ISBN: 007176917X, 9780071769174
3	J.P. Griffin and J. O'Grady; The text book of Pharmaceuutical medicine; New Age International; 5th Ed; 2022; ISBN: 140518035

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: V						
AGRICULTURAL BIOTECHNOLOGY **Category: Professional Core Elective (Group B)** **(Theory)**						
Course Code	**:**	**21BT55B2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39 L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction: History and Scope, 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	**08 Hrs**
Application in Crop improvement: Production of disease plants: shoot tip culture, grafting, Meristem culture and production of virus-free plants. Somatic embryogenesis, Tissue culture as a source of genetic variability – somoclonal and gametoclonal variant selection. Haploids in plant breeding; Anther and microspore culture. Embryo and ovary culture. Somatic hybridization; Protoplast isolation and fusion, cybrids. Somaclonal variation.	
Unit –III	**09 Hrs**
Applications of Genetic Engineering in Agriculture: Preparation and application of molecular probes. Radioactive labelling, Non-radioactive labelling, use of molecular probes, DNA fingerprinting. Agro-bacterium mediated gene transfer,Techniques for the insertion of foreign genes into plant cells. Ti plasmid and vectors, production of transgenic plants: Bt herbicide and virus resistant plants. Application of molecular markers in plant breeding especially in varietal identification; markers assisted selection; QTL mapping and map based cloning.	
Unit –IV	**07 Hrs**
Nanotechnology in Agriculture: Potential applications of nanotechnology in agriculture, relevance, history and applications Production aspects of Nanofertilizers and Nanopesticides. Protected cultivation: Green house technology, Types of Green house, Various component of green house, Design & criteria. Green house irrigation system, Alternative farming strategies: Hydroponics and Aeroponics	
Unit –V	**07 Hrs**
Organic Farming: Biofertilizers: symbiotic Nitrogen fixing bacteria, loose association of N2-fixing bacteria**,** symbiotic Nitrogen -fixing cyanobacteria, Free living Nitrogen fixing bacteria, its importance and applications. **Biopesticide:** Bio fungicides, Bioinsecticides, Biological insecticide and larvicide. Biofungicides: Types, advantages, disadvantages and applications. The potential of organic farming to mitigate the influence of agriculture on global warming. Roof top farming: for improved food and nutrition in urban environment. Integrating agriculture in urban infrastructure.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Remember and explain various fundamentals of Agricultural Biotechnology with reference to breeding techniques and tissue culture
CO2	Apply the knowledge of modern tools to analyse the improvement of agricultural practices and livestock
CO3	Evaluate and analyze various parameters of transgenics for crop and livestock improvement
CO4	Formulate and work on green house and other sustainable techniques

Reference Books	
1	Textbook of Agricultural Biotechnology, Ahidra Nag, 1st edn 2008, PHI Learning, ISBN-13: 978-81-203-3592-9.
2	Agricultural Biotechnology, S Geetha, S Jebaraj and P Pandiyarajan, 2nd edn, 2010 Agrobios ,ISBN 10: 8177543245 / ISBN 13: 9788177543247.
3	Crop Biotechnology, Genetic Modification and Genome Editing, Nigel G Halford 1st edn,2018,World scientific publishers, ISBN: 978-1-78634-530-1
4	Rooftop Urban Agriculture,Orisini, F., dubbeling, M., Zeeuw,H., Gianquinto, C., springer, 2017, ISBN 978-3-319-57720 -3

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: V						
PLANT UTILITIES AND BIOSAFETY **Category: Professional Core Elective (Group B)** **(Theory)**						
Course Code	**:**	**21BT55B3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**8 Hrs**
Water: Sources of water, Impurities in water, Define Hardness and its cause, types of hardness. Water Softening by Zeolite Process, Lime Soda Process, Ion Exchange Process. Water quality standards for bio processes. **Steam:** Brief introduction of steam, formation of steam at a constant pressure from water. Temperature vs total heat graph during steam formation. Steam nozzles, Condensate utilization, Steam traps, Flash tank analysis, Safety valves, Pressure reduction valves.	
Unit – II	**8 Hrs**
Air: Air compressors, Vacuum pumps, Air receivers, Distribution systems, Different types of ejectors, Air dryers, Air purification systems, Requirement of air for different biological reactions, Calculation of Dissolved oxygen. Air quality standards for bio processes.	
Unit –III	**8 Hrs**
Refrigerants and Cooling Water: Introduction, classification of refrigerants (primary, secondary) properties (thermodynamic, physical and safe working,), important refrigerants (ammonia, carbon dioxide, cryogeme, antifreeze). Selection of refrigerants. Construction and working of cooling towers (natural and forced draft).	
Unit –IV	**8 Hrs**
Bio Hazards and Safety: Bio hazards, General principles of industrial Bio safety. Biological Safety Cabinets, Study of various types of Bio safety cabinets. (Design of BSC 1). Biosafety guidelines: Government of India; Definition of GMOs & LMOs, Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture. Overview of National Regulations and relevant International Agreements including; Cartagena Protocol.	
Unit –V	**8 Hrs**
Food safety: Food Hazards, Food Additives, Food Allergens Drugs, Hormones, and Antibiotics in Animals. Factors That Contribute to Foodborne Illness, Consumer Lifestyles and Demand, Food Production and Economics, History of Food Safety, The Role of Food Preservation in Food Safety.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the various utilities for bioprocess industries
CO2	Analyze the water, steam and air requirement for bioprocess industries.
CO3	Evaluate and apply the various risk assessment methods in industries.
CO4	Protect the national biosafety regulations and international agreements in bioprocess industries

Reference Books	
1	Vasandhani, V. P., and Kumar, D. S, Heat Engineering, Metropolitan Book Co. Pvt.Ltd. (2009).
2	Crowl, D.A. and Louvar, J.F., Chemical Process Safety-Fundamentals with Applications, Prentice Hall, (2002)
3	Mujawar. B.A., “A Textbook of Plant Utilities”, Third Edition, Nirali Prakashan Publication, Pune, 1997.
4	Deepa Goel, Shomini Parashar, IPR, Biosafety and Bioethics 1st Edition, Kindle Edition, Person publisher, (2013)

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: V						
SYSTEMS BIOLOGY **Category: Professional Core Elective (Group B)** **(Theory)**						
Course Code	**:**	**21BT55B4**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39 L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction to Systems Biology: Scope, Applications. Concepts, implementation of systems biology. Biological networks build and study models, characterizing dynamic states, Studying dynamic models. Databases for Systems Biology, Mass Spectrometry and Systems Biology. Cell-to-Cell variability, stochastic gene expression, stochastic simulation and modelling. Fick's law, Local excitation and Global inhibition theory in neurons.	
Unit – II	**08 Hrs**
Network Models and Applications: Natural Language Processing and Ontology enhanced Biomedical data mining, text mining. Integrated Imaging Informatics - Integrin, centroid, cell culture. Standard platforms and applications - metabolic control analysis, glycolysis, metabolic network, Michaelis-Menten kinetics. Signal Transduction - phosphorylation, Jak-Stat pathway, MAP kinase. Biological Processes - mitochondria, cyclin, Cdc2. Modeling of Gene Expression - lactose, lac operon, tRNA. Analysis of Gene Expression Data - support vector machines, cDNA microarray. Evolution and Self organization - hypercycle, quasispecies model, self-replication. Reconstruction of metabolic network from Genome Information.	
Unit –III	**08 Hrs**
Integrated Regulatory and Metabolic Models - Phosphorylation, Gene expression, and Metabolites. Estimation Modeling and Simulation - Circadian rhythms, Petri net, mRNA. Deterministic - Circadian rhythms, mRNA, Circadian oscillations. Multi scale representations of Cells and Emerging Phenotypes - Gene Regulatory Networks, attractor, and Boolean functions. Mathematical models and Optimization methods for De Novo Protein design. Global Gene expression assays. Mapping Genotype - Phenotype relationship in cellular networks. Network motifs in biology**.**	
Unit –IV	**08 Hrs**
Multiscale representations of cells and Emerging phenotypes: Multistability and Multicellularity, Spatio-Temporal systems biology, Interactomics, Cytomics – from cell state to predictive medicine. Metagenomics-concept and application of systems biology in metagenomics study. Pathway modelling. Conformational transition in biomolecules revisited (on an evolutionary scale). Metabolism and Metabolic Control Analysis and flux balance analysis.	
Unit –V	**07 Hrs**
Experimental Techniques for Systems Biology: Handling and Interpreting Gene Groups, Functional Interpretation of Gene Groups, Multiple Testing, Softwares, Retrieval and Analysis of Sequences. **The Dynamic Transcriptome of Mice:** Mouse Encyclopedia Project, Technology Used for the Mouse cDNA Encyclopedia: Full-Length cDNA Library Construction, mRNA Elongation Strategies, Avoidance of Internal Cleavage, Selection of FL-cDNAs, Construction of a New Vector, Subtraction and Normalization Technology, High-Throughput Sequence Analysis System: Riken Integrated Sequencing Analysis, New Distribution Method for Transcriptome Resources: The DNA Book, Full-Length cDNA Microarrays, CAGE Technology, GIS and GSC Technologies	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the significant components, emphasizing various software tools and computational methods for systems biology
CO2	Apply genetic networks and models currently used in systems biology.
CO3	Analyze modelling and simulation of various biological processes using bioinformatics tools.
CO4	Demonstrate successful biological models designed using systems biology and also learn about the extend applications of the subject.

Reference Books	
1	Bernhard Ø. Palsson, 'systems biology: simulation of dynamic network states', Cambridge University Press, 2011, ISBN: 9780511736179
2	Corrado Priami. Transactions on Computational Systems Biology I. Springer, Edition 2009. ISBN: 978-3-540-32126-2.
3	Sangdun Choi, Introduction to Systems Biology, Humana Press Inc, Edition 2007, ISBN: 978-1-59745-531-2.
4	Hiroaki Kitano, Foundations of Systems Biology, Massachusetts Institute of Technology, 2001, ISBN 0-262-11266-3.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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**
	TOTAL MARKS	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: V						
ENZYME TECHNOLOGY **Category: Professional Core Elective (Group B)** **(Theory)**						
Course Code	**:**	**21BT55B5**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Purification of Enzymes: Advantages of enzymes vs chemical catalysts, Importance of Enzyme purification, Different sources of enzyme, Extracellular and Intracellular enzyme, Physical and Chemical methods used for cell disintegration, Strategies of purification of enzymes, Assay of enzyme activity and specific activity, fold purification and % yield in purification, criteria of purity, Case studies, Determination of molecular weight of enzymes. Pitfalls in working with pure enzyme.	
Unit – II	**08 Hrs**
Enzyme Kinetics: Enzyme-Ligand interaction, collision theory and transition state theory and role of entropy in catalysis, Methods for investigating the kinetics of Enzyme catalyzed reactions – Initial velocity studies, End point, Steady state and Pre steady state Kinetics, Estimation of Michaelis-Menten parameters. Allostericity and cooperativity. Effect of pH and temperature on enzyme activity.	
Unit –III	**08 Hrs**
Enzyme inhibition: Types of inhibition: competitive, noncompetitive, uncompetitive, mixed, inhibitions. Kinetic differentiation and graphical methods. Examples. Determination of inhibitor constant, therapeutic, diagnostic and industrial applications of enzyme inhibitors.	
Unit –IV	**08 Hrs**
Enzyme Immobilization: Techniques of enzyme immobilization; kinetics of immobilized enzymes, effect of solute, activity & kinetics of immobilized enzymes; applications of immobilized enzyme technology-: Enzyme sensors for clinical analysis, therapeutic medicine, Environmental applications.	
Unit –V	**07 Hrs**
Applications of Enzymes: Textile industry, detergents, pulp and paper, leather, wood, animal feed, food and dairy industry - amylases, proteases, lipases, pectinases. Importance of enzymes in diagnostics, Enzyme pattern in diseases like Myocardial infarctions (SGOT, SGPT & LDH).	

Course Outcomes: After completing the course, the students will be able to	
CO1	Develop strategy for isolation, its purification and measure its activity.
CO2	Measure its kinetic properties, and find the optimum values for parameters affecting enzyme activity.
CO3	Analyse and identify the best method of immobilizing enzymes that can solve the therapeutic challenge.
CO4	Comprehend the applications of enzymes

Reference Books	
1	Enzyme Biocatalysis: Principles and Applications, Andrés Illanes, Springer Netherlands, 2008, ISBN: 1402083602, 9781402083600
2	Advances in Enzyme Technology, A volume in Biomass, Biofuels, Biochemicals 2019, ISBN: 978-0-444-64114-4
3	Principles of Biochemistry, Donald Voet, Judith G. Voet, Charlotte W. Pratt, 4th Edition, 2012, John Wiley & Sons, ISBN-10: 1 9781464126116, ISBN-13: 978-1464126116
4	Enzymes, Biochemistry, Biotechnology, Clinical Chemistry, 2nd Edition - April 4, 2007, T Palmer, P L Bonner, eBook ISBN: 9780857099921

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: V						
INTRODUCTORY MATHEMATICAL METHODS FOR BIOLOGISTS **Category: Professional Elective (Group C - NPTEL Course)** **(Theory)**						
Course Code	**:**	**21BT56C1**		**CIE**	**:**	**50 Marks**
Credits: L:T:P	**:**	**2:0:0**		**SEE**	**:**	**50 Marks**
Total Hours	**:**	**30L**		**SEE Duration**	**:**	**3Hours**

Unit-I	**10 Hrs**
Introduction - Graphs and Functions - Equations as Graphs - Exponential and Periodic Functions - Logarithmic and Other Functions. Overview of mathematical concepts. - Understanding graphs and functions. - Equations represented as graphs. - Exploration of exponential and periodic functions. - Introduction to logarithmic and other functions. Images as 2D/3D Functions - Functions and its Derivatives - Computing Derivatives of Curves - Rules for Calculating Derivatives - Understanding Derivatives. - Representation of images as 2D/3D functions. - In-depth study of functions and their derivatives. - Techniques for computing derivatives of curves. - Rules governing the calculation of derivatives. - Comprehensive understanding of derivatives	
Unit – II	**10 Hrs**
Curvature and Second Derivative - Plotting Curves - Numerical Calculation of Derivatives - Function, Derivatives, and Series Expansion - L'Hopital's Rule and Partial Derivatives. - Exploring curvature and second derivatives. - Practical aspects of plotting curves. - Numerical methods for calculating derivatives. - Relationship between functions, derivatives, and series expansion. - Application of L'Hopital's Rule and understanding partial derivatives. Exponential growth and Decay - Scalars and Vectors - Vectors: Position and Movement in 2D - Cell Symmetry: Use of Polar Coordinates - Gradient, Forces, and Flows: Part I and II - Understanding Diffusion - Diffusion Constant and Einstein Relation 1905 - Diffusion Equation - Diffusion vs. Active Transport. - Analysis of exponential growth and decay. - Understanding scalars and vectors. - Application of vectors to position and movement in 2D. - Exploring cell symmetry and the use of polar coordinates. - In-depth study of gradient, forces, and flows. - Comprehensive understanding of diffusion, including its constant, the Einstein Relation of 1905, the diffusion equation, and a comparison with active transport.	
Unit –III	**10 Hrs**
- Nernst Equation - Fourier Series: Part I and II - Fourier Transform - Introduction to Statistics - Basics of Bio-Statistics. - Application of Nernst Equation. - Understanding Fourier Series and Transform. - Introduction to statistical concepts. - Basics of bio-statistics including mean, standard deviation, distribution, frequency distribution, probability distribution, binomial distribution, normal distribution, hypothesis testing, and mathematical modeling.	

Course Outcomes: After completing the course, the students will be able to	
CO 1:	Proficiency in solving complex quantitative problems using mathematical concepts and techniques.
CO 2:	Ability to apply mathematical principles across diverse scientific domains.
CO 3:	Analysis and interpretation of mathematical representations and functions.
CO 4:	Articulating mathematical concepts and problem-solving approaches.

Reference Books	
1.	Mathematics for Biological Scientists, M. Aitken, B. Broadhursts, S. Haldky, Garland Science (2009)

Semester: V						
BIOENGINEERING: AN INTERFACE WITH BIOLOGY AND MEDICINE **Category: Professional Elective (Group C – NPTEL Course)** **(Theory)**						
Course Code	**:**	**21BT56C2**		**CIE**	**:**	**50 Marks**
Credits: L:T:P	**:**	**2:0:0**		**SEE**	**:**	**50 Marks**
Total Hours	**:**	**30L**		**SEE Duration**	**:**	**3Hours**
Unit-I						**10 Hrs**
Introduction to Bioengineering, The need of biology for engineer, Life processes and Cell, Cell and its properties, Cell division and proliferation Clinician's Perspectives. Sources of information of biological origin, gene and protein sequences, sequence homology and its biological significance DNA Tools-Gene cloning, DNA Tools used in Biotechnology,						
Unit – II						**10 Hrs**
Understandings of Genetics, Clinician's Chromosomal basis of inheritance, Linkage, chromosomal disorders, Classical Genetics experiments, genetic distances, chromosome, mapping, natural selection, crossovers and recombination, Bacteria and Viruses. Cell cycle, Cell cycle deregulations & Cancer, Developmental Biology, Principles and application of Animal Cloning, Evolution & Bioinformatics						
Unit –III						**10 Hrs**
Cell cycle, Cell cycle deregulations and Cancer, Developmental Biology, Principles and application of Animal Cloning, Evolution & Bioinformatics, Amino acids and proteins, Proteins & Proteomics, Techniques to Study Protein & Proteome-I,II,III and IV. Protein Interactions & Microarrays, Protein interactions & Systems biology						

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Explain the link between bioengineering and clinician perspectives
CO2	Apply the principles of DNA tools used in biotechnology
CO3	Comprehend the genetics and its application for bioinformatics.
CO4	Apply the protein and proteomics and protein interactions

Reference Books	
1.	J. Y. Wong, J. D. Bronzino, Biomaterials, CRC Press (2019), first Edition, ISBN:9780429116520
2.	Sandy B. Primrose, Richard Twyman Principles of Gene Manipulation and Genomics, 7th Edition 2006 Wiley-Blackwell, ISBN: 978-1-405-13544-3 .
3.	A M Campbell & L J Heyer Discovering Genomics, Proteomics & Bioinformatics Pearson Education, 2007, ISBN:978-0805347227.

Semester: V						
BIO INTERPHASE ENGINEERING **Category: Professional Elective (Group C - NPTEL Course)** **(Theory)**						
Course Code	**:**	**21BT56C3**		**CIE**	**:**	**50 Marks**
Credits: L:T:P	**:**	**2:0:0**		**SEE**	**:**	**50 Marks**
Total Hours	**:**	**30L**		**SEE Duration**	**:**	**3Hours**

Unit I	**10 Hrs**
Intermolecular Forces and Adhesion and Wetting Phenomena: Introduction to Intermolecular Forces, Classification of Intermolecular Forces, Thermodynamics Aspects of Intermolecular Forces, Surface Tension and Energy, Wettability, Adhesion and Cohesion	
Unit 2	**10 Hrs**
Characterization of Interfaces and Protein-Surface Interactions: Methods for Surface Tension Measurement, Methods for Contact Angle Measurement, Determination of Surface Tension of Solids, Protein Adsorption, Characterization of Protein Adsorption, Kinetics of Protein Adsorption, Aggregation of Proteins, Kinetics of Protein Aggregation, Effect of Surfaces on the Aggregation of Protein	
Unit 3	**10 Hrs**
Protein Aggregation and cell surface interactions: Host Responses to Biomaterials, Cell Adhesion, Biocompatibility of Biomaterials. Surface Modification and Characterization-I and II : Surface Modification, Surface Modification Techniques, Coating of Calcium Phosphates on Ti-6Al-4V , Surface Characterization, Self-Assembled Monolayers, Effect of SAMs on Bio interfacial Interactions	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Study various thermodynamic laws on the intermolecular forces of compounds
CO2	Measure the surface tension of the compounds
CO3	Apply the adsorption behaviour on the protein aggregations
CO4	Learn the various characterization techniques for surface layers

Reference Books	
1.	J. N. Israelachvili, Intermolecular and Surface Forces, 3rd Edition, Academic Press, 2011.
2.	Willem Norde, Colloids and Interfaces in Life Sciences and Bio nanotechnology, 2nd Edition, CRC Press, 2011.
3.	W. Adamson, and A. P. Gast, Physical Chemistry of Surfaces, John Wiley, New York, 1997

Semester: V						
DATA ANALYSIS FOR BIOLOGISTS **Category: Professional Elective (Group C - NPTEL Course)** **(Theory)**						
Course Code	**:**	**21BT56C4**		**CIE**	**:**	**50 Marks**
Credits: L:T:P	**:**	**2:0:0**		**SEE**	**:**	**50 Marks**
Total Hours	**:**	**30L**		**SEE Duration**	**:**	**3Hours**

Unit-I	**10 Hrs**
Rules of probability, Discrete probability distribution, Continuous probability distribution, Statistics using R ,Äì Descriptive Statistics, Moments: variance and covariance, Linear Algebra using R, Concept of statistical tests. Vector and vector operations, Matrix and matrix operations, Determinant and Inverse of a matrix, Eigenvalue and eigenvector, Linear system of equations, Singular value decomposition.	
Unit – II	**10 Hrs**
Getting ready with R, Algebraic and logical operations in R, Reading and writing data, Statistics using R â€“ descriptive statistics, Statistics using R â€“ t-test and ANOVA, Linear algebra using R, Scatter plot, Line plot & Bar plot, Histogram & Box plot, Heatmap and Volcano plot, Network visualization, Data visualization using ggplot2 – I, Data visualization using ggplo2 – II, Correlations, Linear regression, Linear regression using R, Multiple linear regression, multiple linear regression using R.	
Unit –III	**10 Hrs**
Nonlinear regression, Nonlinear regression using R, Clustering and classification, Logistic regression, Logistic regression using R, Distance mesaures for clustering, k-means clustering, k-means clustering using R, Hierarchical clustering, Hierarchical clustering using R, Decision tree classifier, Support vector machines, Higher-dimensional data in biology, Principle component analysis, Principle component analysis using R, Statistics using R ,Äì Descriptive Statistics, t-SNE using R, Linear Algebra using R.	

Course Outcomes: After completing the course, the students will be able to	
CO 1:	Proficiency in solving complex quantitative problems using mathematical concepts and techniques.
CO 2:	Ability to apply analytical principles across diverse scientific domains.
CO 3:	Analysis and interpretation of analytical representations and functions.
CO 4:	Elucidating the analytical concepts and problem-solving approaches.

Reference Books	
1.	Data analysis for biologists. Biplab Bose. NPTEL (2023)

Semester: V						
NANOTECHNOLOGY IN AGRICULTURE **Category: Professional Elective (Group C - NPTEL Course)** **(Theory)**						
Course Code	**:**	**21BT56C5**		**CIE**	**:**	**50 Marks**
Credits: L: T:P	**:**	**2:0:0**		**SEE**	**:**	**50 Marks**
Total Hours	**:**	**30L**		**SEE Duration**	**:**	**3Hours**

Unit-I	**10 Hrs**
Introduction to nanotechnology in Agriculture: especially precision agriculture. Conventional versus modern agriculture w.r.t to cropping seasons, selection of crops, fertilizers, pesticides, herbicides. History of nanotechnology in Agriculture, Nanoparticle classification, Approaches to nanomaterial synthesis: Physical, Chemical and Biological methods of synthesis.	
Unit – II	**10 Hrs**
Characterization of Nanomaterials: Techniques for physical and chemical surface properties of a material, Nanomaterials in Agriculture – For seed treatment, case studies for lab and field trials. Mechanism of pyrite nanoparticles in different crops. Applications of different nanoparticles in Agriculture and its benefits.	
Unit –III	**10 Hrs**
Nanotechnology in Animal Production: Nanomaterials in animal production, Antioxidant nanomaterials for skeletal muscle development. Summary of nanomaterials in animal production. Nanomaterials in food processing and preservation. Multifunctionality of nanomaterials: water purification, waste disposal and energy. Sustainable and green nanotechnology. Case study of titanium dioxide. The future- evolving Nanoworld.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the role of nanotechnology in precision agriculture
CO2	Apply the characterization techniques and use of nanomaterials in agriculture
CO3	Evaluate various nanomaterials for better animal production
CO4	Formulate the proof of concept for sustenance and green nanotechnology for global outreach

Reference Books	
1.	Precision Agriculture Technologies for Food Security and Sustainability. Sherine M. Abd El-Kader, Basma M. Mohammad El-Basioni.2021.IGI Global publisher. ISBN: 978179985000
2.	Precision Agriculture: Technology and Economic Perspectives. Pedersen, Søren Marcus, Lind, Kim Martin. 2017. Springer International Publishing. ISBN 978-3-319-68713-1
3.	Nanotechnology Trends and Future Applications, Tahir, Muhammad Bilal, Rafique, Muhammad, Sagir, Muhammad, 2021, Springer, (Eds.), ISBN 978-981-15-9437-3.

Semester: V						
SUMMER INTERNSHIP - II (Practical)						
Course Code	:	21BTI57		**CIE**	:	**50 Marks**
Credits: L: T: P	:	0:0:2		**SEE**	:	**50 Marks**
Total Hours	:	4 Weeks		**SEE Duration**	:	**02 Hrs**
Students can opt the internship with the below options						4 Weeks

A. Within the respective department at RVCE (Inhouse) Departments may offer internship opportunities to the students through the available tools so that the students come out with the solutions to the relevant societal problems that could be completed within THREE WEEKS.

B. At RVCE Center of Excellence/Competence

RVCE hosts around 16 CENTER OP EXCELLENCE in various domains and around 05 CENTER OP COMPETENCE. The details of these could be obtained by visiting the website https:/ /rvce.edu.in / rvce-center-excellence. Each centre would be providing the students relevant training/internship that could be completed in three weeks.

C. At InternShala

Intern Shala is India's no.1 internship and training platform with 40000+ paid internships in Engineering. Studentscan opt any internship for the duration of three weeks by enrolling on to the platform through https: / /internshala.com

D. At Engineering Colleges nearby their hometown

Students who are residing out of Bangalore, should take permission from the nearing Engineering College of their hometown to do the internship. The nearby college should agree to give the certificate and the letter/email statingthe name of the student along with the title of the internship held with the duration of the internship in their officialletter head.

E. At Industry or Research Organizations

Students can opt for interning at the industry or research organizations like BEL, DRDO, ISRO, BHEL, etc.. through personal contacts. However, the institute/industry should provide the letter of acceptance through hard copy/email with clear mention of the title of the work assigned along with the duration and the name of the student.

Procedures for the Internship:

1. Request letter/Email from the office of respective departments should go to Places where internships are intended to be carried out with a clear mention of the duration of Three Weeks. Colleges/Industry/ CoEs/CoCs will confirm the training slots and the number of seats allotted for the internship via confirmation letter/ Email.
2. Students should submit a synopsis of the proposed work to be done during internship program. Internship synopsis should be assessed or evaluated by the concerned Colleges/Industry/CoEs/CoC. Students on joining internship at the concerned Colleges/Industry/ CoEs/CoCs submit the Daily log of student's dairy from the joining date.
3. Students will submit the digital poster of the training module/project after completion of internship.
4. Training certificate to be obtained from industry.

Course Outcomes: After completing the course, the students will be able to: -	
CO1	Develop interpersonal, critical skills, work habits and attitudes necessary for employment.
CO2	Assess interests, abilities in their field of study, integrate theory and practice and explore career opportunities prior to graduation.
CO3	Explore and use state of art modern engineering tools to solve the societal problems with affinity towards environment and involve in ethical professional practice.
CO4	Compile, document and communicate effectively on the internship activities with the engineering community.

RUBRICS FOR THE CONTINUOUS INTERNAL EVALUATION		
#	COMPONENTS	MARKS
1.	**REVIEW I:** Explanation of the application of engineering knowledge in industries, abilityto comprehend the functioning of the organization/ departments, exhibiting professional and ethical practice, communication skills (oral and body language).	**20**
2.	**REVIEW II**: Presentation in the form digital poster, report writing, exhibiting ethics inreport writing, oral presentation.	**30**
MAXIMUM MARKS FOR THE CIE THEORY		**50**

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	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: VI						
INTELLECTUAL PROPERTY RIGHTS AND ENTREPRENEURSHIP (Common to all Programs) (Theory)						
Course Code	**:**	21HSI61A		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	40L		**SEE Duration**	**:**	**3Hours**

Unit-I	**09 Hrs**

Introduction: Types of Intellectual Property

Patents: Introduction, Scope and salient features of patent; patentable and non-patentable inventions, Patent Procedure - Overview, Transfer of Patent Rights; protection of traditional knowledge, Infringement of patents and remedy, Case studies

Patent Search and Patent Drafting, Commercialization and Valuation of IP. Case examples.

Unit – II	**08 Hrs**

Trade Secrets: Definition, Significance, Tools to protect Trade secrets in India.

Trade Marks: Concept, function and different kinds and forms of Trade marks, Registrable and non- registrable marks. Registration of Trade Mark; Deceptive similarity; Transfer of Trade Mark, ECO Label, Passing off, Infringement of Trade Mark with Case studies and Remedies. Case Examples.

Unit –III	**08 Hrs**

Industrial Design: Introduction of Industrial Designs Features of Industrial, Design. Procedure for obtaining Design Protection, Revocation, Infringement and Remedies, Case studies.

Copy Right: Introduction, Nature and scope, Rights conferred by copy right, Copy right protection, transfer of copy rights, right of broad casting organizations and performer's rights, Exceptions of Copy Right, Infringement of Copy Right with case studies.

Introduction to Cyber law: Information Technology Act, cybercrime and e-commerce, data security, confidentiality, privacy, international aspects of computer and online crime.

Unit –IV	**09 Hrs**

Entrepreneurship: Introduction, Evolution of the Entrepreneurship, Importance of Entrepreneurship, Concept of Entrepreneurship, Characteristics of a successful Entrepreneur, Classification of Entrepreneur, Myths of Entrepreneurship, Entrepreneurial Development Models, Problems Faced by Entrepreneurs and Capacity Building for Entrepreneurship .Women Entrepreneurship in Asia, Women Entrepreneurship in India, Challenges Faced by Women Entrepreneurs. Case studies.

Entrepreneurship in the New Age: Getting to know your Business, it's Eco-system and Environment, Passion and Values driving, building and growing Family businesses, Challenges and suggested management approaches.

Unit –V	**11 Hrs**

Business Plans: Introduction ,Purpose of a Business Plan ,Contents of a Business Plan, Business Concept, Business Strategy, Marketing Plan, Operations Plan, Financial Plan, Presenting a Business Plan, Oral and Visual Presentation, Why Do Some Business Plans Fail? Procedure for Setting Up an Enterprise, Business Models and Business Model Innovation Creating a Business Plan. Case lets/Case studies.

Preparation of project: Meaning of Project; Project Identification; Project Selection; Project Report; Need and Significance of Report; Contents; formulation; Guidelines by Planning Commission for Project report; Network Analysis; Errors of Project Report; Project Appraisal. Identification of. Business Opportunities: Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study. Use of standard templates for preparation of project report.

Reference Books	
1.	Intellectual Property Rights: Unleashing Knowledge Economy, Prabuddha Ganguly, 1st Edition, 2001, Tata McGraw Hill Publishing Company Ltd., New Delhi, ISBN: 0074638602.
2.	Intellectual Property and the Internet, Rodney Ryder, 2002, Lexis Nexis U.K., ISBN: 8180380025, 9788180380020.
3.	Poornima M. Charantimath "Entrepreneurship Development and Small Business Enterprise", Pearson Education, 2005, ISBN: 9788177582604
4.	Dynamics of Entrepreneurial Development & Management-Vasant Desai, Himalaya Publishing House, 6th Edition, 2018, ISBN - 978-93-5299-133-4
5.	Entrepreneurial development, Khanka, Shobhan Singh, S. Chand Publishing, 2006, ISBN - 8121918014, 9788121918015

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Comprehend the applicable source, scope and limitations of Intellectual Property within the purview of engineering domain.
CO2	Knowledge and competence related exposure to the various Legal issues pertaining to Intellectual Property Rights with the utility in engineering perspectives.
CO3	Enable the students to have a direct experience of venture creation through a facilitated learning environment.
CO4	It allows students to learn and apply the latest methodology, frameworks and tools that entrepreneurs use to succeed in real life.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)* (Small case lets and case example in one subdivision)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
REACTION ENGINEERING **Category: Professional Core Course** **(Theory and Practice)**						
Course Code	**:**	**21BT62**		**CIE**	**:**	**100 +50 Marks**
Credits: L:T:P	**:**	**3:0:1**		**SEE**	**:**	**100 +50 Marks**
Total Hours	**:**	**39L+30P**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction: Classification of reactions, molecularity and order of reaction, rate equation and rate of reaction, elementary and non-elementary reactions, Arrhenius law (excluding mechanism of reactions).numericals.	
Unit – II	**08 Hrs**
Homogeneous reactions: Analysis of batch experimental reactor data: Evaluation of rate equation. Integral and differential analysis for constant and variable volume system (zero, 1st and 2nd order irreversible reactions).numericals.	
Unit –III	**08 Hrs**
Design of ideal reactors: Concept of ideality, Type of reactors, space time, mean residence time, development of design expressions for batch, tubular and stirred tank reactors for both constant and variable volume systems. numericals	
Unit –IV	**08 Hrs**
Multiple reactors: Size comparison of reactors, Analysis of different types of ideal reactors in series and parallel combination (Only irreversible reactions), Design of combination of reactors, optimum combination of reactors.	
Unit –V	**07 Hrs**
Non Ideal Flow: Interpretation of RTD curve: C, E and F curves, step and impulse input response for the non ideal reactors. Exit age distribution of fluid in reactors, RTD's for CSTR and PFR, calculation of conversion for first order reaction. numerical	

Lab Experiments

1. To find the order and rate constant for a reaction between non-equimolar quantities of in a batch reactor
2. To find the order and rate constant for a reaction between non-equimolar quantities of in a CSTR
3. To find the order and rate constant for a reaction between equimolar quantities of in a batch reactor
4. To find the order and rate constant for a reaction between equimolar quantities of in a CSTR
5. To carryout RTD studies using PFR by introducing tracer in pulse input mode
6. To carryout RTD studies using PFR by introducing tracer in step input mode
7. To carryout RTD studies using CSTR by introducing tracer in pulse input mode
8. To carryout RTD studies using CSTR by introducing tracer in step input mode
9. To find the order and rate constant for a reaction between non-equimolar quantities of a reaction in a semi batch reactor
10. To estimate the rate constant of a reaction at different temperatures in a batch reaction

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the rate law and determine the parameters of rate expression for homogeneous reactions
CO2	Apply design equations for the three ideal reactors (batch, CSTR and plug flow) for single reactions
CO3	Design the multiple reactors involved in homogeneous chemical reaction.
CO4	Analyze the RTD data, plot C,E,F curves and determine mean residence time, variance, skewness and conversion for ideal and real reactors

Reference Books	
1	Octave Levenspiel; Chemical Reaction Engineering; John Wiley and Sons; 3rd Edition; 3rd ed; 1999. ISBN: 0-471-25424-X
2	H.S Fogler; Elements of Chemical Reaction Engineering; Prentice Hall; 4th ed; 2006. ISBN:0130473944
3	P.M. Doran; Bioprocess Engineering Principles; Academic Press; 2nded; 2012. ISBN:978012220851
4	M.E.Davis and R.E. Davis, Fundamentals of Chemical Reaction Engineering, McGraw Hill Education, 1st ed., 2003.ISBN 0-07-119260-3

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY AND PRACTICE)		
#	**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 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**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks**. THE FINAL MARKS WILL BE 50 MARKS**	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: VI						
PLANT AND ANIMAL BIOTECHNOLOGY **Category: Professional Core Course** **(Theory and Practice)**						
Course Code	**:**	**21BT63**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**3:0:1**		**SEE**	**:**	**100+50 Marks**
Total Hours	**:**	**39L+30P**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Cell culture systems in Plants and Animals: Introduction to plant and animal culture, Culture types; callus, cell suspension culture, kinetics of cell cultures. Micropropagation; Direct Organogenesis and Indirect Organogenesis, Molecular mechanisms Somatic embryogenesis, Haploids, Somatic Hybridisation .Biotic and abiotic elicitation of important secondary metabolites, Biotransformation. **Principles of animal and cell culture:** Types of cells, Culturing of cells, primary and secondary cell lines, kinetics of cell growth, Cell lines and their applications. Techniques of cell culture, Types of culture media. Cytotoxicity. **Scale-up studies:** Types of bio-reactors used for animal cell and plant cell cultures.	
Unit – II	**07 Hrs**
Applications of Plant biotechnology: Molecular farming/pharming. Improvement of Product Quality; Nutritional Improvements. Pharmaceutical Products; plantibodies, enzymes, therapeutic proteins, edible vaccines, bio plastics, and other novel compounds. Genetic manipulation of fruit ripening and delay (Case study –tomato), flower color (Case study- Anthurium and Gerbera).	
Unit –III	**08 Hrs**
Applications of Animal biotechnology: Animal Breeding techniques: Artificial insemination; In vitro fertilization and embryo transfer, advantages of cell manipulation techniques. Animal cloning. Animal cells as bioreactors - therapeutic proteins - enzymes – vaccines applications of transgenic animals for the production of recombinant proteins, transgenic animals- transgenic cattle - transgenic goat and pigs. Gene Therapy-Prospects and problems; Knockout mice and mice model for human genetic disorder.	
Unit –IV	**08 Hrs**
Meta transcriptomic and metaproteomic analysis: Introduction, Tools and Data bases for NGS Design, Development and deployment of work flows for Genome assembly and genome mapping, network analysis, differential gene expression assay, Variant calling in plant and animal genome, QTL Linkage studies, Genome wide detection of Plant and animal promoters	
Unit –V	**07 Hrs**
Omics in Plant and animal world:: Systems Biology approach to study plant and animal systems. Functional Genomics, Proteomics and Metabolomics. Ethical and safety norms involved in plant and animal biotechnology.	

LABORATORY EXPERIMENTS

1. Callus and cell suspension culture and elicitation studies from various explants, In- vitro shoot and
2. root regeneration
3. Extraction and estimation of total phenolics and flavonoids
4. Extraction and estimation of lycopene from tomato.
5. Cell viability test
6. Extraction of plant metabolites and assessment of anti-inflammatory properties.
7. PAL enzyme assay in Cell cultures and Antioxidant assay in cultures
8. Detection of metabolic pathways responsible for dental caries formation.
9. Study of Differential gene expression in rice (irrigated and semi irrigated)
10. Variant calling in cancer genome
11. Purification of Hb proteins from blood

Open ended Experiment: Genetic transformation in plants (in planta and tissue culture based). Screening and Selection of transformants (GUS Assay and PCR using GUS specific primers).

Course Outcomes: After completing the course, the students will be able to	
CO1	Comprehend the principles of Microbial, plant and animal cell biotechnology and techniques
CO2	Apply modern techniques to produce clones/heterologous compounds/genetically modified organisms
CO3	Screen and Analyse the products/heterologous compounds/genetically modified organisms.
CO4	Design/develop methodology for production of clones/compounds/genetically modified organisms

Reference Books	
1	C. Neal Stewart, Jr.Plant Biotechnology and Genetics: Principles, Techniques, and Applications.Wiley publishers. 2nd Edition. 2016.ISBN: 9781118820124.
2	Arie Altman, Paul Hasegawa.Plant Biotechnology and Agriculture. Academic Press 2012. 1st Edition. ISBN: 9780123814661.
3	Microbial Biotechnology: Fundamentals of applied microbiology, Glazer AN, Nikaido, Cambridge University Press, 2nd Edition, 2007, ISBN 978-0-52184210-5
4	Textbook of Animal Biotechnology - P. R. Yadav, Discovery Publishing House, First Edition, ISBN No: 9788183564953, 2016.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY AND PRACTICE)		
#	**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 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**
4.	**LAB:** Conduction of laboratory exercises, lab report, observation, and analysis (30 Marks), lab test (10 Marks) and Innovative Experiment/ Concept Design and Implementation (10 Marks) adding up to 50 Marks**. THE FINAL MARKS WILL BE 50 MARKS**	**50**
	MAXIMUM MARKS FOR THE CIE (THEORY AND PRACTICE)	**150**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

RUBRIC FOR SEMESTER END EXAMINATION (LAB)		
Q.NO.	**CONTENTS**	**MARKS**
1	Write Up	**10**
2	Conduction of the Experiments	**20**
3	Viva	**20**
	TOTAL	**50**

Semester: VI						
BIOMEDICAL INSTRUMENTATION **Category: Professional Core Elective** **(Theory)**						
Course Code	**:**	**21BT64D1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction to Medical Instrumentation: Sources of biomedical signals, basics of medical instrumentation systems, different bioelectrical signals. Transducers: Definition, classification and biomedical applications. Bio Electrodes, types, key Properties of Bio electrodes, Resting and Action potential, Propagation of Action potential. Ventilators and its importance.	
Unit-II	**08 Hrs**
Cardiovascular Measurements: Anatomy of heart, cardiac cycle, Measurement of blood pressure, characteristics of Electrocardiogram (ECG), Block diagram, description, lead configuration and types of recorders. Blood flow meters, electromagnetic, ultrasonic, NMR and laser Doppler blood flow meters. **Biotelemetry**: Wireless telemetry, single channel / multi-channel telemetry, Applications and advantages of biotelemetry	
Unit-III	**08 Hrs**
Blood Gas Analysers: Acid–base Balance, pCO2, pO2, Complete blood gas analyser, Pulse oximeter, ear, fingertip oximetry, skin reflectance oximetry. Blood cells counters: methods – Microscopic, coulter counter. **Audiometers:** types of Audiometers, Mechanism of hearing, requirements of audiometer, calibration and applications of audiometer	
Unit-IV	**08 Hrs**
Diagnostic And Medical Imaging Systems: X-Ray: general principles of Imaging, Instrumentation Special imaging techniques for X-rays. Magnetic Resonance imaging (MRI): general principles of MRI, Instrumentation, Magnet design, Magnetic field gradient coils, radiofrequency coils, Clinical application of MRI. Computer Tomography (CT) Scan: Purpose, Procedure, Risks, and its Side-Effects	
Unit-V	**08 Hrs**
Therapeutic Equipment: Cardiac pacemakers: External and Implantable pacemakers, Cardiac defibrillators: AC/DC and Implantable defibrillators. Nerve and muscle stimulator, Diathermy: shortwave, microwave and ultrasonic wave. Ultrasonic Imaging System: General principle of Ultrasonic Imaging and Instrumentation, , Diagnostic scanning modes, Biological effect of ultrasound	

Course Outcomes: After completing the course, the students will be able to	
CO1	Comprehend the necessity and sources of biomedical signals and instruments to measure them
CO2	Identify different parameters to measure the heart and brain functioning leading to diagnostic applications.
CO3	Use of potential non-invasive imaging systems in medical diagnosis.
CO4	Application of the bio medical instrumentation to diagnose and to treat human diseases

References Books	
1.	Anandanatarajan .R. Biomedical Instrumentation and Measurements. PHI Pub. 2011. ISBN: 978-81-203-4227-9.
2.	Khandpur R.S. Biomedical Instrumentation Technology and Applications McGraw –Hill Pub. First Edition, 2012.ISBN-9780071777469.
3.	Shakti. Chatterjee, Aubert Miller. Biomedical Instrumentation Systems. Delmar cengage learning Pub.2011.ISBN:13-978-1418018-665
4.	Mandeep Singh. Introduction to Biomedical Instrumentation. PHI Pub., 2010. ISBN: 9788120341630

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
FOOD & DAIRY BIOTECHNOLOGY **Category: Professional Core Elective** **(Theory)**						
Course Code	**:**	**21BT64D2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39 L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Food Processing and Preservation: Thermal Preservation: Mild and severe heat treatment, Effect of heat on microorganisms. Non thermal: Refrigeration, freezing, Dehydration. Food irradiation: irradiation, regulations, advantage and limitations of food irradiation, nutritional and microbiological changes in irradiated foods. High pressure processing of foods: principles, applications to food systems, effect on quality – textural, nutritional and microbiological quality – factors affecting the quality. High pressure freezing: principles and applications. Ultrasound processing of foods: principle of ultrasound, ultrasound as a processing and preservation aid, effect on properties of foods. Minimal processing and hurdle technology: Principle and applications.	
Unit – II	**08 Hrs**
Food Microbiology: Sources of microorganisms in foods and their effective control. Chemical changes caused by microorganisms: Changes in nitrogenous organic compounds, Non-nitrogenous organic compounds, organic acids, other compounds, lipids, pectic substances. Microbial toxins: Bacterial toxins, fungal toxins, algal toxins and mushroom toxins. Food borne intoxications and infections: types of food involved, toxicity and symptoms.	
Unit –III	**08 Hrs**
Food Additives, Preservatives, Packaging and quality standards: Food Additives: Definition, function, major additives used in processing, nutrient supplements. Food preservatives- types, effects on health. Packaging: Functions, packaging materials, Types of packaging, active packaging technologies. Post-harvest preservation of raw food materials.	
Unit –IV	**08 Hrs**
Introduction to Dairy technology: Components of milk: Lactose, salts, lipids, enzymes, natural components. Properties of milk: solution properties, acidity, redox potential, flavors, density, optical properties and viscosity Microbiology of milk: general aspects: bacteria yeast, mold, undesirable microorganisms: pathogenic and spoilage microorganisms. Hygienic measures against spoilage of milk. Methods and procedures for sampling and testing of milk and milk products. Laws and standards for milk and milk products.	
Unit –V	**07 Hrs**
Milk Processing: Cream separation, pasteurization, sterilization and homogenization. Technology for the manufacture of evaporated milk, condensed milk, dried milk, malted milk, infant and baby foods ice cream cheese butter fermented milk and indigenous dairy products. Butter, cheese and yoghurt: properties and manufacture. Packaging: properties and filling operation. Gas packaging and modified atmosphere packages. Quality control Product safety in food packaging	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the food components in detail for the healthier society
CO2	Analyse the various food preservation techniques and its effect.
CO3	Apply the techniques learnt for milk analysis and its preservation
CO4	Evaluate the milk processing and food packaging techniques

Reference Books	
1	Vaclavik VA and Christian EW. 2014 Essentials of food science,4th Edition NY, ISBN: 978-1461491378
2	Parker R 2003 Introduction to Food Science. Albany NY, Delmar. 1st Edition, ISBN: 9780766813144
3	Pieter Walstra, Jan T. M. Wouters and Tom J. Geurts. 2006. Dairy Science and Technology, Taylor Francis, 2nd ed., ISBN: 978-0-8247-2763-5
4	Selia, dos Reis Coimbra and Jose A. Teixeira. 2010. Engineering Aspects of Milk and Dairy Products , CRC Press, 1st ed., ISBN: 978-1-4200-9022-2

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
FERMENTATION TECHNOLOGY **Category: Professional Core Elective** **(Theory)**						
Course Code	**:**	**21BT64D3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**36L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**07 Hrs**
INTRODUCTION: Background of fermentation- history, 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, Strain development for primary, secondary and recombinants, Mode of fermentation operation: batch, fed batch and Continuous.	
Unit – II	**07 Hrs**
FERMENTATION MEDIA: Raw Materials and Sterilization: Selection of typical raw materials, Different types of media fermentation, Optimization of media- Plackett and Burman method, Different sterilization methods batch sterilization, continuous sterilization, Air filter sterilization. **INOCULUM DEVELOPMENT**: Preparation of Inoculum: methods, Inoculum preparation from laboratory scale to pilot scale and large-scale fermentation, case study for fungal and bacterial cultures.	
Unit –III	**07 Hrs**
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.	
Unit –IV	**08 Hrs**
AERATION AND AGITATION: Oxygen requirement and Supply of oxygen, fluid rheology, Estimation of Kla by sulphite oxidation technique, Static method of gassing out, Dynamic Methods of Gassing out and Oxygen balance technique (only final equations and graphical analysis), factors affecting Kla and aeration & agitation. **SCALE-UP**: Scale-up of fermentation process, Factors considered for the scale-up process. Scale-Down Process	
Unit –V	**07 Hrs**
FERMENTATION ECONOMICS AND CASE STUDIES: Understanding of Process economics, Beer manufacturing process, Streptomycin production, Vitamin B12, Lipase enzyme production and Recombinant human insulin production. Effluent treatment methods for fermentation industries.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Remember and understand the techniques for isolating the industrial important microorganism for production various biotechnological products
CO2	Implement the fermentation principles, Process and its parameters for optimized yield
CO3	Analyze the scale up techniques, process economics and effluents management
CO4	Execute the fermentation for small molecules through case studies

Reference Books	
1	P. Stanbury, A Whitaker. and S. Hall. Principles of Fermentation Technology; Aditya Books Pvt Ltd. New Delhi; 2ndedn; 2003. ISBN: 8185353425.
2	E. M. T. El-Mansi, C. F. A. Bryce., Fermentation Microbiology and Biotechnology, CRC Press. Third Edition, 12 Jan 2012 ISBN-13: 978-1439855799.
3	Br Ian McNeil, Linda Harvey., "Practical Fermentation Technology", John Wiley &Sons. 2008, ISBN: 0470725281.
4	Pauline M. Doran., "Bioprocess Engineering Principles", 2nd Edition, Academic press, 2012, ISBN: 978-0-12-220851-5.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
PROGRAMMING IN BIOTECHNOLOGY **Category: Professional Core Elective** **(Theory)**						
Course Code	**:**	**21BT64D4**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40 L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**

Introduction to Java:

Java and Java applications. Java Development Kit (JDK). Java Basics - Data Bytes, Operators, Statements and Object-oriented programming. Classes, Inheritance. Classes in Java - Declaring a class, Constructors and Creating instances of class. Super classes and Inner classes. Inheritance - Simple, multiple, and multilevel inheritance; Overriding, overloading. Exception Handling and Exception Classes in Java..

Unit – II	**08 Hrs**

Multi-Threaded Programming, Event Handling:

Multi Programming: Extending threads; Implementing rentable. Synchronization, Changing state of the thread. Bounded buffer problems, Read-write problem, Producer-Consumer problems. Event Handling: Two event handling mechanisms, Delegation event model, Event classes; Sources of events; Event listener interfaces. Delegation event model; Adapter classes; Inner classes. Eevnt handling for Buttons, Text boxes, List boxes, radio buttons, Check boxes, slide bars and menu options.

Unit –III	**08 Hrs**

Java 2 Enterprise Edition:

The Concept of JDBC; JDBC Driver Types; JDBC Packages; A Brief Overview of the JDBC process; Database Connection; Associating the JDBC/ODBC Bridge with the Database; Statement Objects; ResultSet; Transaction Processing; Metadata, Data types; Exceptions. Servlets: Background; The Life Cycle of a Servlet; Simple Servlet; The Servlet API. The Javax. Servlet Package. Reading Servlet Parameter, Handling HTTP Requests and Responses. Cookies and Session Tracking.

Unit –IV	**08 Hrs**

Automation of NGS applications in JAVA:

Implementation of Major workflows in JAVA for Genomics, Genome Annotation, Functional Annotation of Proteins, Meta-genomics, Meta-transcriptomics, Meta-Proteomics, High-Throughput Virtual Screening, Variant Calling.

Unit –V	**08 Hrs**

BioJava:

Working with Nucleic Acid and Protein Sequences - create, read, compare sequences. Working with Protein Structures - fetching, parsing PDB structures, Calculating structure alignment, interacting with Jmol. Sequence alignment - performing global, local and multiple sequence alignment. BioJava and Next Generation sequencing Analysis.

Course Outcomes: After completing the course, the students will be able to	
CO1	Define and explain concepts of Object Oriented Programming along with Threading, Event management, Database connectivity as well as Web programming
CO2	Apply Threading, Event management, Database connectivity as well as Web programming to solve the problems in the area of Big Data Analytics
CO3	Analyse and evaluate efficiency threading and multithreading with case studies
CO4	Design and implement basic algorithms to perform high throughput data analysis in the field Sequence and structure analysis

Reference Books	
1	Peter Garst, Mastering Java Through Biology - A Bioinformatics Project Book, BookBaby 2014, ISBN: 9781483534404.
2	Jens Dörpinghaus, Vera Weil, Sebastian Schaaf, Computational Life Sciences - Data Engineering and Data Mining for Life Sciences, Springer International Publishing 2023, ISBN: 9783031084119.
3	Herbert Schildt, Java: The Complete Reference, Eleventh Edition, McGraw Hill LLC 2018, ISBN: 9781260440249
4	Perry Xiao, Practical Java Programming for IoT, AI, and Blockchain, Wiley 2019, ISBN: 9781119560012.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
EQUIPMENT DESIGN AND DRAWING **Category: Professional Core Elective** **(Theory)**						
Course Code	**:**	**21BT64D5**		**CIE**	**:**	**100**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3 Hrs**

Unit-I	**08 Hrs**
Detailed Process Design and mechanical design of Fermenter using standard code book. The detailed dimensional drawings using CAED shall include sectional front view, Full Top/Side view depending on equipment and Major component drawing with dimensioning and Part Template.	
Unit – II	**08 Hrs**
Detailed Process Design and mechanical design of Jacketed vessel using standard code books. The detailed dimensional drawings using CAED shall include sectional front view, Full Top/Side view depending on equipment and Major component drawing with dimensioning and Part Template.	
Unit –III	**08 Hrs**
Detailed Process Design and mechanical design of packed bed distillation column using standard code book. The detailed dimensional drawings using CAED shall include sectional front view, Full Top/Side view depending on equipment and Major component drawing with dimensioning and Part Template.	
Unit –IV	**08 Hrs**
Detailed Process Design and mechanical design of Shell and Tube heat exchanger using standard code books. The detailed dimensional drawings using CAED shall include sectional front view, Full Top/Side view depending on equipment and Major component drawing with dimensioning and Part Template.	
Unit –V	**08 Hrs**
Detailed Process Design and mechanical design of Adsorption column using standard code book. The detailed dimensional drawings using CAED shall include sectional front view, Full Top/Side view depending on equipment and Major component drawing with dimensioning and Part Template.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Remember and understand the concepts of design and use of the IS 2825 code book and J H Perry hand book
CO2	Integrate the standard design parameters to design of bio equipment.
CO3	Evaluate the various parameters of distillation column, bio reactors and adsorption column
CO4	Generate drawings of distillation column, bio reactors and adsorption column.

Reference Books	
1	R.H. Perry & D.W. Green, Chemical Engineers Handbook, 7th Edition, McGraw Hill 2008;ISBN: 780071422949
2	IS 2825 Code: Unfired pressure vessels, BIS New Delhi.
3	M.V. Joshi and V.V. Mahajan, Design of Process Equipment Design, 4th Edition , McMillan India 2009; ISBA: 978-0230638105
4	J.M. Coulson & J.F. Richardson, Chemical Engineering Vol. 6, Pregman Press, 1993; ISBN 07506 65386

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	The SEE question paper contains two questions each for 100 marks. The student has to choose any one of the question.	**100**

Semester: VI						
NANOBIOTECHNOLOGY **Category: Professional Core Elective – Cluster Elective** **(Common to BT, CV, and CH)** **(Theory)**						
Course Code	**:**	**21BT65E1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39 Hrs**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**07 Hrs**
Introduction to Nanomaterials History, Types of nanomaterials: Fullerenes (Grephene, Bucky ball, Nano tubes, Diamond like carbon, DLC), Nanoshells, Quntum dots, Dendrimers, Nanocarriers. Nanowires. **Nanobiomaterials:** Introduction & overview of 1st generation 2nd generation & 3rd generation biomaterials, DNA and Protein based Nano structures, array nanostructures. Function and application of DNA and protein based nanostructures.	
Unit – II	**08 Hrs**
Nanomaterials, Synthesis and Characterization: Approaches of Fabrication: Top-Down and Bottom-up methods of nanofabrication and Nanosynthesis: Ball milling, CVD, Sol gel, Plasma arching. Biosynthesis of Nanoparticles. Nanolithography: hard (Optical, UV, EUV, X-ray) and soft lithography. Characterization of nanomaterials using spectroscopic (UV-VIS, FTIR and Raman) and microscopic methods Atomic Force Microscopy, Scanning & Tunneling Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy (AFM, STM, SEM and TEM).	
Unit –III	**07 Hrs**
Nanosensors and Nanobiosensors: Overview of nanosensors, prospects and market. Types of Nanosensors and their applications. Electromagnetic nanosensors: Magnetic nanosensors. Mechanical nanosensors. Types of nanobiosensors: Cantilever, nanotube, nanowire and nanoparticle based sensor, Nanosensors, Biosensors in modern medicine.	
Unit –IV	**07 Hrs**
Micro & Nano Electromechanical systems and Microfluidics: MEMS/NEMS: Nanotransducers: Nano-mechanical, electrical, electronic, Magnetic and Chemical Transducers. Nano sensors and Nano Actuators: types of actuators. Microfludics: Laminar flow, Hagen- Peouiselle equation, basic fluid ideas, Special considerations of flow in small channels, mixing, microvalves & micropumps.	
Unit –V	**10 Hrs**
Medical Nano Technology: Diagnostics, therapeutics, drug delivery, Nano Surgery and Tissue Engineering. Diagnostics: Resonance Light Scattering (RLS) Technology, Nano chips, gene and protein chips. Therapeutic: Drug delivery: Bioavailability, Drug Delivery Applications, Bioavailability, Sustained and targeted release. Benefits of Nano drug delivery system. Use of Microneedles and nanoparticles for targeted and highly controlled drug delivery. Nano robots in drug delivery and cleaning system. Design of nanoparticles for oral delivery of peptide drugs, Tissue Engineering.. Nanotoxicity assessment: In-vitro laboratory tests on the interaction of nanoparticles with cells. Body on a chip and lab on a chip.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Remember, understand and apply knowledge about nanomaterials and their uses. Interpret and apply the techniques of manufacturing and characterization processes.
CO2	Understand the Micro & Nano Electromechanical systems and Microfluidics Interpret and apply the techniques and processes.
CO3	Understand and apply knowledge of nanosensors and nanobiosensors applications like electronics, mechanical, chemical, and biological systems
CO4	Apply knowledge of nanosensors and nanobiosensors to create and evaluate nano- design, devices and systems applicable to various disciplines.

Reference Books	
1	Textbook of Nanosciences and Nanotechnology, B.S. Murty, P. Shankar, B. Raj, B. B. Rath and J. Murday, 2013, Springer, Co-publication with University Press (India)Pvt. Ltd. VCH, XII. ISBN- 978-3-642-28030-6.
2	Springer Handbook of Nanotechnology**,** Editors: Bhushan, Bharat (Ed.), 2017,Springer, ISBN 978-3-662-54357-3.
3	Nanotechnology and Nanomaterial Applications in Food, Health, and BiomedicalSciences (Innovations in Agricultural & Biological Engineering), Deepak KumarVerma, Megh R. Goya, Hafiz Anasr Rasul Suleria, 2019, Apple Academic Press,CRC Press, Taylor & Francis Group**,** ISBN-10 1771887648.
4	Nanotechnology Trends and Future Applications, Tahir, Muhammad Bilal, Rafique,Muhammad, Sagir, Muhammad, 2021, Springer, (Eds.), ISBN 978-981-15-9437-3.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
NATURE IMPELLED TECHNOLOGIES **Category: Professional Core Elective – Cluster Elective** **(Common to BT, CV, and CH)** **(Theory)**						
Course Code	**:**	**21BT65E2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39 L**		**SEE Duration**	**:**	**03 Hours**

Unit-I	**06 Hrs**
Nature-inspired materials: Bioinspiration, bio-imitation and biomimicry. Emerging trends and prospects: Nature-inspired processes, Nature-inspired design approach, nature-inspired materials by virtue of the gain; Design and functionality, engineering and manufacturing and materials.	
Unit – II	**08 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, Plantoid ; Robotic Solutions Inspired by Plant Root. Plant cockleburs and Velcro.	
Unit –III	**08 Hrs**
Nature 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 -optical tweezers.	
Unit –IV	**08 Hrs**
Nature driven technologies for industrial applications: Biosensors, Thermal insulation and storage materials. Bio-robotics; design, control actuation and sensing. Human inspired hyper dynamic manipulation. Humanoid Robot.	
Unit –V	**08 Hrs**
Nature inspired computing: Cellular automata, evolutionary computing, swarm intelligence, artificial life and complex networks. Genetic Algorithms, Artificial Neural Networks. Artificial intelligence and MEMS.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Elucidate the concepts and phenomenon of natural processes
CO2	Apply the basic principles for design and development of nature inspired structures
CO3	Analyse and append the concept of bio-mimetics for diverse applications
CO4	Designing technical solutions by utilization of natured-inspiration modules.

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 (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
BIO-ENERGY TECHNOLOGY **Category: Professional Core Elective – Cluster Elective** **(Common to BT, CV, and CH)** **(Theory)**						
Course Code	**:**	21CH65E1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	40L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction: Bioresources: Definition, examples, and classification. Opportunities and challenges. Global trends in bioresource technology. Classification of bioresource technology. Biomass: Synthesis, significance, world energy scenario, physico-chemical properties, composition, and characteristics.	
Unit – II	**08 Hrs**
Conversion Technologies 1: Introduction, conversion technologies for biomass into energy. Comparison between various thermochemical conversion technologies. Comparison between biological and thermo-chemical conversions. Combustion. Pyrolysis. Gasification.	
Unit –III	**08 Hrs**
Conversion Technologies 2: Anaerobic Digestion: Introduction, potential benefits, process and pathway, Factors affecting, Advantages and disadvantages, Anaerobic co-digestion, Bio gasification of cow dung. Design of anaerobic digester	
Unit –IV	**08 Hrs**
Biofuels: Introduction, Pre-treatment of LCB, biofuel types, relevance of biofuel technology. Sources of liquid biofuels for automobiles. Bioethanol, Bio-aviation Turbine Fuel, Bio-pulping. Biogas.	
Unit –V	**08 Hrs**
Case studies: Ethanol production from starchy crops and lignocellulosic biomass. Bio methanation of water hyacinth for biogas production, Butanol production from lignocellulosic biomass. Biodiesel from Jatropa	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Describe the nature and principle of different biomass energy extraction systems.
CO2	Identify how to choose the suitable biomass fuels for different bio-energy applications
CO3	Recognize drivers and barriers for biofuel production
CO4	Develop sustainable biofuel production considering ecological and socio-economic criteria

Reference Books	
2.	Mark Crocker (Ed.), 2010. Thermochemical Conversion of Biomass to Liquid Fuels and Chemicals. RSC Publishing, ISBN:9781849730358
2.	Donald L. Klass, 1998. Biomass for Renewable Energy, Fuels and Chemicals. Academic Press, San diego, CA. ISBN: 978-0-12-410950-6
3.	Daizo Kunii and Octave Levenspiel. Fluid ization Engineering, 2nd Edition. Butterworth-Heinemann series in Chemical Engineering. ISBN 0-409-90233-0 1
4.	Charles E. Wyman (Ed.), 1996. Handbook on Bioethanol: Production and Utilization. CRC Press, New York. ISBN 1-56032055304
5	Brigit Kamm, Patrick R. Gruber and Michael Kamm (Ed.), 2008. Biorefineries -Industrial Processes and Products: Status Quo and Future Directions, Vol. 1 & 2. Wiley-VCH, Weinheim, Germany.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
HYDROGEN TECHNOLOGY **Category: Professional Core Elective – Cluster Elective** **(Common to BT, CV, and CH)** **(Theory)**						
Course Code	**:**	21CH65E2		**CIE**	**:**	**100**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100**
Total Hours	**:**	40L		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Hydrogen: Peculiarity and Types Salient features of hydrogen, properties of hydrogen, terminology and types of hydrogen, advantages, disadvantages, comparison with other fuels, and global status of supply and demand	
Unit – II	**08 Hrs**
Hydrogen Generation Generation of different types of hydrogen, conventional methods, nonconventional methods, generation from non-renewable sources, generation from renewable sources and challenges	
Unit –III	**08 Hrs**
Hydrogen Storage Storage as compressed gas, storage as cryogenic liquid, storage as metal hydrides, storage through liquid organic hydrogen carriers, and storage in carbon nano tubes	
Unit –IV	**08 Hrs**
Hydrogen Handling and Safety Classification of hydrogen hazards, compressed and liquid hydrogen related hazards, regulation, codes and standards related to hydrogen handling and transport, personal protective equipment	
Unit –V	**08 Hrs**
Hydrogen Applications Applications of hydrogen in various sectors such as refineries, petrochemicals, fertilizer industries, steel industries, transport and automotive sectors	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the importance of hydrogen and its use as an energy carrier
CO2	Explain the production, storage and handling of hydrogen
CO3	Analyze the need for hydrogen as an alternate fuel and the associated challenges
CO4	Appraise the importance of safety, regulations and codes

Reference Books	
3.	Hydrogen Fuel: Production, Transport and Storage, Gupta, R. B., CRC Press, Taylor & Francis Group, 1st Edition, 2009, ISBN: 9780429147364
2.	Hydrogen Production: Electrolysis, Agata Godula-Jopek, Wiley-VCH, 1st Edition, 2015, ISBN:9783527333424
3.	Handbook of Hydrogen Storage, Michael Hirscher, Wiley-VCH, 1st Edition, 2010, ISBN:9783527322732
4.	Fuel Cell Systems Explained, James Larminie and Andrew Dicks, John Wiley & Sons, 2nd Edition, 2003, ISBN 978 0470 848579

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
DISASTER MANAGEMENT **Category: Professional Core Elective – Cluster Elective** **(Common to BT, CV, and CH)** **(Theory)**						
Course Code	**:**	21CV65E1		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	36L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**08 Hrs**
Natural disasters and Disaster management -Introduction to natural and Industrial Hazards- floods, landslides, earthquakes, volcanoes, avalanche, cyclones, drought, fire, release of effluents, harmful gases, Blast etc. Prediction and perception. Environmental risk due to project activities. Preparation of on-site and off-site disaster management plans - Pre disaster, actual disaster, Post disaster plans. Relief camp organization. Role of voluntary organization and armed forces during disasters.	
Unit – II	**08 Hrs**
Risk analysis and assessment Basic concept. Purpose of risk analysis. Analytical techniques and tools of risk assessment. Toxicology. Significance of risk. Risk characterization. Risk communication and Management, AI in emergency responses	
Unit –III	**08 Hrs**
Environmental Impact Assessment (EIA) Definition, Basic concepts and principles of EIA, Regulatory framework in India, Environmental inventory, Base line studies. Over view of EIA studies. **Assessment and Methodologies** Physical, Biological, Natural resources, Socio economic and cultural environmental assessment, Checklist approaches, Public participation in environmental decision making. Procedures for reviewing EIA analysis and statement. Decision methods for evaluation of alternatives.	
Unit –IV	**08 Hrs**
Disaster Mitigation Measures Basic principles, early warning systems, building design and construction in highly seismic zones, retrofitting of building, Usage of Remote sensing and GIS techniques, Awareness programs, Assessment on preparedness for disaster, Regional and global disaster mitigation, Mitigation Plans and Guidelines	
Unit –V	**08 Hrs**
Disaster Management Techniques Introduction, types, modes of disaster management, tools and techniques, primary and secondary data. Natural disasters its causes and remedies-Earthquake hazards-Causes and remedies, Flood and Drought assessment, causes and remedies, Landslides-causes and remedies. Fire hazards in buildings, Fire hazard management, Traffic management, inter department cooperation.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Study the environmental impact of natural and manmade calamities
CO2	Learn to analyse and assess risk involved due to disasters.
CO3	Understand the role of public participation.
CO4	Learn the management and mitigation tools and techniques

Reference Books	
1	Environmental Impact Analysis Hand Book, John G Rau and David C Wooten, Edition: 2013, ISBN: 978-0070512177.
2	Introduction to environmental Impact assessment, John Glasson, RikiTherivel, Andrew Chadwick, Edition: 2012, Research Press, ISBN:000-0415664705.2005, Reliance Publishing House, New Delhi
3	Natural Disaster Reduction, Girish K Mishrta, G C Mathew (eds), Edition, 2005, Reliance Publishing House, New Delhi
4	Remote Sensing and Image Interpretation, Thomas M. Lillisand and R.W. Keifer, 6th Edition, 2002, John Wiley, ISBN:9780470052457

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	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 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 THEORY	**100**

ASSESSMENT AND EVALUATION PATTERN		
WEIGHTAGE	**50%**	**50%**
QUIZZES		
Quiz-I	Each quiz is evaluated for 10 marks adding up to **20 MARKS.**	*****
Quiz-I		
THEORY COURSE (Bloom's Taxonomy Levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating)		
Test – I	Each test will be conducted for 50 Marks adding upto 100 marks. Final test marks will be reduced to **40 MARKS**	*****
Test – II		
EXPERIENTIAL LEARNING	**40**	*****
Case Study-based Teaching-Learning	**10**	*****
Sector wise study & consolidation	**20**	
Video based seminar (4-5 minutes per student)	**10**	
MAXIMUM MARKS FOR THE THEORY	**100 MARKS**	**100 MARKS**
TOTAL MARKS FOR THE COURSE	**100**	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
SOLID WASTE MANAGEMENT **Category: Professional Core Elective – Cluster Elective** **(Common to BT, CV, and CH)** **(Theory)**						
Course Code	**:**	21CV65E2		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	40L		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**08 Hrs**
Introduction: Land Pollution due to improper solid waste management. Merits and demerits of present and scientific solid waste disposal methods. Scope and importance of solid waste management. Definition and functional elements of solid waste management. **Sources**: Sources of Solid waste, types of solid waste, composition of municipal solid waste. Generation rate, Numerical Problems.	
Unit – II	**08 Hrs**
Collection and transportation of municipal solid waste: Collection of solid waste- services and systems, Primary and secondary collection and transportation equipments. Route optimization. Solid waste management rules with amendments. Site visit to collection system. Numerical problems	
Unit –III	**08 Hrs**
Composting Aerobic and anaerobic composting - process description, process microbiology, Vermicomposting, Numerical problems, Site visit to compost plant. **Sanitary landfilling:** Definition, advantages and disadvantages, site selection, methods, reaction occurring in landfill- Gas and Leachate movement, Control of gas and leachate movement, Site visit to landfill site.	
Unit –IV	**08 Hrs**
Hazardous waste management: Definitions, Identification of hazardous waste, Classification of hazardous waste, onsite storage, collection, transfer and transport, processing, disposal, Recent hazardous waste (management, handling) rules with amendments. Site visit to hazardous landfill site	
Unit –V	**08 Hrs**
Bio medical waste management: Impact of improper biomedical waste on health and environment. Classification of bio medical waste, collection, transportation, disposal of bio medical waste, Recent Bio medical waste management rules with amendments. site visit to hospital to see the collection and transportation system and visit to biomedical waste incineration plant **Plastic waste management:** Types of plastic and its uses. Impact of plastic waste on land, marine and wild life, Greener alternatives to plastic, Recent Plastic waste management rules with amendments.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the existing waste management system and to identify their drawbacks.
CO2:	Identify the adverse effects of improper waste management on environment.
CO3:	Evaluate and monitor the flow of waste as per the rules laid by Ministry of Environment and Forest.
CO4:	Design Recycling and scientific disposal options for different types of waste.

Reference Books	
1	Integrated Solid Waste Management: Engineering principles and management issues George Tchobanoglous, Hilary Theisen , Samuel A Vigil, published by M/c Graw hill Education . Indian E Edition 2014. ISBN – 13: 978- 9339205249, ISBN-10 : 9339205243
2	Environmental Engineering, Howard S Peavy, Donald R Rowe and George Tchobanoglous, Tata Mcgraw Hill Publishing Co ltd., 2013, ISBN-13 9789351340263.
3	Municipal Solid waste (Management & Handling Rules). Ministry of Environment & Forest Notification, New Delhi.
4	Hazardous waste (Management& Handling Rules). Ministry of Environment & Forest Notification, New Delhi.
5	Bio medical waste management rules. Ministry of Environment & Forest Notification, New Delhi.
6	Plastic waste management rules. Ministry of Environment & Forest Notification, New Delhi.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
INDUSTRIAL SAFETY AND RISK MANAGEMENT **Category: Institutional Elective (Group – F)** **(Theory)**						
Course Code	**:**	**21IE6F1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3Hours**

Unit-I	**08 Hrs**
Introduction Safety: Introduction to industrial safety engineering, major industrial accidents, safety and health issues, key concepts and terminologies, Hazard theory, Hazard triangle, Hazard actuation, Actuation transition, Causal factors, Hazard recognition.	
Unit – II	**08 Hrs**
Risk assessment and control: Individual and societal risks, Risk assessment, Risk perception, Acceptable risk, ALARP, Prevention through design. **Hazard Identification Methods:** Preliminary Hazard List (PHL): Overview, methodology, worksheets, case study. Preliminary Hazard Analysis (PHA), Fault tree and Event tree analyses.	
Unit –III	**08 Hrs**
Hazard analysis: Hazard and Operability Study (HAZOP): Definition, Process parameters, Guide words, HAZOP matrix, Procedure, Example. Failure Modes and Effects Analysis (FMEA): Introduction, system breakdown concept, methodology, example.	
Unit –IV	**08 Hrs**
Application of Hazard Identification Techniques: Case of pressure tank, heat exchanger, system breakdown structure, Accident paths, HAZOP application, risk adjusted discounted rate method, probability distribution, Hiller's model	
Unit –V	**08 Hrs**
Safety in process industries and case studies: Personnel Protection Equipment (PPE): Safety glasses, face shields, welding helmets, absorptive lenses, hard hats, types of hand PPE, types of foot PPE, types of body PPE. Bhopal gas tragedy, Chernobyl nuclear disaster, Chemical plant explosion and fire.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Recall risk assessment techniques used in process industry
CO2	Interpret the various risk assessment tools.
CO3	Use hazard identification tools for safety management.
CO4	Analyze tools and safety procedures for protection in process industries.

Reference Books	
1.	Functional Safety in the Process Industry: A Handbook of practical Guidance in the application of IEC61511 and ANSI/ISA-84, Kirkcaldy K.J.D Chauhan, 2012, North corolina,Lulu publication, ISBN:1291187235.
2.	Safety Instrumented Systems Verification Practical probabilistic calculations, Goble and William M., 2005, Pensulvania ISA publication, ISBN:155617909X.
3.	Industrial safety and risk Management, Laird Wilson and Doug Mc Cutche, 1st Edition, 2003,The University of alberta press,Canada, ISBN: 0888643942.
4.	ndustrial Safety, Health and Environment Management Systems, R K Jain, Sunil S Rao, 4th Edition, 2005, Khanna Publishers, New Delhi, ISBN: 8174092102.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**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.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
RENEWABLE ENERGY SYSTEMS **Category: Institutional Elective (Group – F)** **(Theory)**						
Course Code	**:**	**21IE6F2**		**CIE**	**:**	**100Marks**
Credits: L:T:P	**:**			**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction: Energy systems model causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification, Renewable Energy – Worldwide Renewable Energy Availability, Renewable Energy in India. **Basics of Solar Energy:** Sun- earth Geometric Relationship, Layer of the Sun, Earth – Sun Angles and their Relationships, Solar Energy Reaching the Earth's Surface, Solar Thermal Energy Application. Block diagram of solar energy conversion.	
Unit – II	**08 Hrs**
Solar PV Systems: Basic Principle of SPV conversion – Types of PV Systems(Standalone, Grid connected, Hybrid system)- Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array ,PV Module I-V Characteristics, Array design (different methodologies),peak-power operation, system components.Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking, Applications..	
Unit –III	**08 Hrs**
Wind Power Systems: **Wind speed and energy:** Introduction, history of wind energy, scenario- world and India. Basic principle of Wind energy conversion system (WECS), Classifications of WECS, part of a WECS. Derivation of power in the wind, electrical power output and capacity of WECS, wind site selection consideration, advantages and disadvantages of WECS. Maximum energy capture, maximum power operation, , environmental aspects.	
Unit –IV	**08 Hrs**
Geothermal and ocean energy systems: Geothermal well drilling, advantages and disadvantages, Comparison of flashed steam and total flow concept (T-S diagram). Associated Problems, environmental Effects. **Energy from ocean:** OTEC power generation, OPEN and CLOSED cycle OTEC. Estimate of Energy and power in simple single basin tidal and double basin tidal system. Issues Faced in Exploiting Tidal Energy	
Unit –V	**08 Hrs**
Hydrogen Energy: Benefits of Hydrogen Energy, Hydrogen Production through block diagram, Use of Hydrogen Energy, Merits and Demerits, Problems Associated with Hydrogen Energy. **Biomass Energy:** Introduction-Biomass resources –Energy from Biomass: conversion processes-Biomass Cogeneration- Environmental Benefits. Biomass products – ethanol, biodiesel, biogas Electricity and heat production by biomass.	

Course Outcomes: After completing the course, the students will be able to: -	
CO 1	Understand the working principle and operation of various renewable energy sources and systems.
CO 2	Analyze the performance and characteristics of renewable energy sources and systems.
CO 3	Evaluate the parameters of wind and solar energy systems.
CO 4	Design and demonstrate the applications of renewable energy sources in a typical systems.

Reference Books	
1.	Solar photo voltaic Technology and systems, by Chetan Singh Solanki, 3rd Edition, PHI, Learning private limited New Delhi, 2013, ISBN: 978-81-203-4711-3.
2.	Wind and solar power system design, Analysis and operation, Mukund R. Patel, 2nd Edition. CRC Group, Taylor and Francis group, New Delhi, ISBN 978-0-8493-1570-1.
3.	Renewable energy: Technology, Economics and Environment, Martin Kaltschmitt, Wolfgang Streicher Andreas Wiese, Springer Publication, 2007, ISBN 978-3-540-70947- 3

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
SYSTEMS ENGINEERING **Category: Institutional Elective (Group – F)** **(Theory)**						
Course Code	**:**	**21IE6F3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45 Hrs**		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**06 Hrs**
System Engineering and the World of Modem System: What is System Engineering?, Origins of System Engineering, Examples of Systems Requiring Systems Engineering, System Engineering viewpoint, Systems Engineering as a Profession, The power of Systems Engineering, problems. **Structure of Complex Systems:** System building blocks and interfaces, Hierarchy of Complex systems, System building blocks, The system environment, Interfaces and Interactions. **The System Development Process:** Systems Engineering through the system Life Cycle, Evolutionary Characteristics of the development process, The system engineering method, Testing throughout system development, problems.	
Unit – II	**10 Hrs**
Systems Engineering Management: Managing systems development and risks, Work breakdown structure (WBS), System Engineering Management Plan (SEMP), Risk Management, Organization of Systems Engineering, Systems Engineering Capability Maturity Assessment, Systems Engineering standards, Problem. **Needs Analysis:** Originating a new system, Operations analysis, Functional analysis, Feasibility analysis, Feasibility definition, Needs validation, System operational requirements, problems. **Concept Exploration:** Developing the system requirements, Operational requirements analysis, Performance requirements formulation, Implementation concept exploration, Performance requirements validation, problems.	
Unit –III	**10 Hrs**
Concept Definition: Selecting the system concept, Performance requirements analysis, Functional analysis and formulation, Concept selection, Concept validation, System Development planning, System Functional Specifications, problems **Advanced Development:** Reducing program risks, Requirements analysis, Functional Analysis and Design, Prototype development, Development testing, Risk reduction, problems.	
Unit –IV	**10 Hrs**
Engineering Design: Implementing the System Building blocks, requirements analysis, Functional analysis and design, Component design, Design validation, Configuration Management, problems. **Integration and Evaluation:** Integrating, Testing and evaluating the total system, Test planning and preparation, System integration, Developmental system testing, Operational test and evaluation, problems.	
Unit –V	**09 Hrs**
Production: Systems Engineering in the factory, Engineering for production, Transition from development to production, Production operations, Acquiring a production knowledge base, problems. **Operations and support**: Installing, maintenance and upgrading the system, Installation and test, In-service support, Major system upgrades: Modernization, Operational factors in system development, problems.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understand the Life Cycle of Systems.
CO2	Explain the role of Stake holders and their needs in organizational systems.
CO3	Develop and Document the knowledge base for effective systems engineering processes.
CO4	Apply available tools, methods and technologies to support complex high technology systems.

Reference Books:	
1.	Alexander Kossoaikoff, William N Sweet, "Systems Engineering – Principles and Practice" John Wiley & Sons, Inc, Edition: 2012, ISBN: 978-81-265-2453-2
2.	Andrew P. Sage, William B. Rouse, "Handbook of Systems Engineering And Management" John Wiley & Sons, Inc., Edition:1999, ISBN 0-471-15405-9
3.	Ludwig von Bertalanffy, "General System Theory: Foundation, Development, Applications", Penguin University Books, 1973, Revised, ISBN: 0140600043, 9780140600049.
4.	Blanchard, B., and Fabrycky, W. Systems Engineering and Analysis, Saddle River, NJ, USA: Prentice Hall, 5th E Edition, 2010.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
MECHATRONICS **Category: Institutional Elective (Group – F)** **(Theory)**						
Course Code	**:**	**21IE6F4**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45 Hrs**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**09 Hrs**
Overview of Mechatronic Systems: Traditional and mechatronic design, automatic washing machine, automatic door dishwasher, compact disc drive copy machine, camera and temperature control. Principle and working of hall sensor displacement sensor, absolute and incremental encoders, photoelectric sensors, inductive and capacitive proximity sensors, Relays and solenoids, Brushless DC, AC and servo motors, pulse width modulation by basic transistor circuit H bridge circuit, Stepper motor: variable reluctance and permanent magnet, stepper motor control circuits, selection of motors.	
Unit – II	**10 Hrs**
Signal Conditioning: Operational Amplifiers - circuit diagrams and derivation - Numerical, filtering, multiplexers, 4:1 MUX, time division multiplexing -seven segment display, data acquisition, Analog and digital signals, analog to digital converters. Introduction to Digital signal processing – difference equation (Numericals). **Programmable logic controllers:** Components, principle of operation, modifying the operation, basic PLC instructions, and concepts of ladder diagram, latching, timer instructions, counter instructions.	
Unit –III	**10 Hrs**
Ladder Diagram for PLCs: Examples with ladder logic programs, simple programs using Boolean logic, word level logic instructions. Relay to ladder conversion examples., **Industrial applications of PLCs:** Central heating system, valve sequencing, traffic light control in one direction, water level control, overhead garage door, sequential process, continuous filling operation, Fluid pumping with timers, parking garage counter, can counting in assembly line.	
Unit –IV	**08 Hrs**
Microcontrollers: Components of a full featured microcontroller, Memory, I/O Ports, Bus, Read & Write Cycle Architecture of Intel 8051 microcontroller, Pin diagram, simple instructions for a microcontroller. – Data transfer arithmetic functions, logical operations, Jump and branching operation. **Digital circuits:** Digital representations, Combinational logic - Case studies: BCD to 7 segment decoder, calenda subsystem in a smartwatch., timing diagrams, Karnough maps – 3 variable and 4 variable, design of logic networks flip-flops, Counters.	
Unit –V	**08 Hrs**
Dynamic Responses of Systems: Closed loop system, Terminology, transfer functions, step response of first order and second order systems, performance measures for first and second order systems, - Numerical **Mechanical Actuation Systems:** Four bar chain, slider crank mechanism, Cams and followers, gear trains - Numerical	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Select appropriate sensors and transducers and devise an instrumentation system for collecting information about processes
CO2	Apply the electrical and logic concepts and inspect the functioning of mechatronic systems.
CO3	Evaluate a control system for effective functioning of Mechatronics systems using digital electronics, microprocessors, microcontrollers and programmable logic controllers
CO4	Develop conceptual design for Mechatronics products based on potential customer requirements

Reference Books	
1.	Nitaigour Premchand, 'Mechatronics-Principles, Concepts & Applications', TMH 1st Edition, 2009, ISBN: 9780070483743
2.	Bolton W., 'Mechatronics-Electronic Control System in Mechanical and Electrical Engineering', Pearson Education, 4th Edition, 2012; ISBN:9788131732533
3.	**Tilak Thakur 'Mechatronics', Oxford University Press, I Edition, 2016, ISBN: 9780199459329**
4.	Petruzella, Frank D, Programmable logic controllers, McGraw-Hill, 4th Edition, 2013, ISBN-13: 978-0-07-351088-0

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**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.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
MATHEMATICAL MODELLING **Category: Institutional Elective (Group – F)** **(Theory)**						
Course Code	**:**	**21IE6F5**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L**		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**09 Hrs**
Continuous Models Using Ordinary Differential Equations: Basic concepts, real world problems (Science and Engineering), approximation of the problem, steps involved in modelling, formation of various continuous models.	
Unit – II	**09 Hrs**
Mathematically Modelling Discrete Processes: Difference equations - first and second order, introduction to difference equations, introduction to discrete models-simple examples, mathematical modelling through difference equations in economics, finance, population dynamics, genetics and other real-world problems.	
Unit –III	**09 Hrs**
Markov modelling: Mathematical foundations of Markov chain, applications of Markov modelling.	
Unit –IV	**09 Hrs**
Modelling through graphs: Graph theory concepts, modelling situations through different types of graphs.	
Unit –V	**09 Hrs**
Variational Problem and Dynamic Programming: Optimization principles and techniques, mathematical models of variational problem and dynamic programming and applications.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explore the fundamental concepts of mathematical models arising in various fields of engineering.
CO2:	Apply the knowledge and skills of discrete and continuous models.
CO3:	Analyze the appropriate mathematical model to solve the real-world problem and optimize the solution
CO4:	Distinguish the overall knowledge gained to demonstrate the problems arising in many practical situations.

Reference Books	
1	Mathematical Modeling, J. N. Kapur, 1st Edition, 1998, New Age International, New Delhi, ISBN: 81-224-0006-X.
2	Mathematical Modeling: Models, Analysis and Applications, Sandip Banerjee, 2014, Chapman and Hall/CRC Textbook, ISBN 9781439854518.
3	Case Studies in Mathematical Modeling, D. J. G. James and J. J. Mcdonald, 1981, Stanly Thames, Cheltonham, ISBN: 0470271779, 9780470271773.
4	Modeling with Difference Equations, D. N. Burghes, M. S. Borrie, Ellis Harwood, 1981, ISBN 13: 9780853122869.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: Question 3 or 4	16
5 & 6	Unit 3: Question 5 or 6	16
7 & 8	Unit 4: Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
INDUSTRY 4.0 - SMART MANUFACTURING FOR THE FUTURE **Category: Institutional Elective (Group – F)** **(Theory)**						
Course Code	**:**	**21IE6F6**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**42 L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**07 Hrs**
Introduction: The Various Industrial Revolutions, Need – Reason for Adopting Industry 4.0, Definition, Goals and Design Principles – Interoperability, Virtualization, Decentralization, Real-time Capability, Service Orientation, Modularity. Individualization, Volatility, Energy and resource efficiency. Road to Industry 4.0 - Internet of Things (IoT), Architecture of IoT, Technologies for IoT & Industrial Internet of Things (IIoT), Internet of Services, Standardization, Cyber-Physical Systems, Smart Manufacturing, Network via Ethernet/ Wi-Fi for high-speed data transmission, Mobile technologies	
Unit – II	**10 Hrs**
Opportunities and Challenges: Lack of resources, Availability of skilled workers, Broadband infrastructure, Policies, Future of Works and Skills in the Industry 4.0 Era, Disruption as manufacturing's greatest modern challenge **Robotics in Industry 4.0:** Robotic Automation and Collaborative Robots, Human-Machine Interaction **Big Data:** Evolution**,** Essential of Big Data in Industry 4.0, Big Data Merits, Data transparency, Business Intelligence, Production planning, Quality, Acquisition of Automation Data, Digital Traceability, Radio-Frequency Identification (RFID), GPS, Data transformation, Big Data Characteristics, Data as a new resource for organizations, Data driven applications, Harnessing and sharing knowledge in organizations, Data analytics - Descriptive Analytics, Diagnostic analytics, Predictive Analytics, Prescriptive analytics	
Unit –III	**10 Hrs**
Cloud Computing : Fundamentals, Cloud/Edge Computing and Industry 4.0, The IT/OT convergence, Cyber Security **Horizontal and Vertical integration:** End-to-end engineering of the overall value chain, Digital integration platforms, Role of machine sensors, Sensing classification according to measuring variables, Machine-to-Machine communication **Artificial Intelligence/Machine Learning in Industry 4.0:** Fundamentals, Case Studies, Technology paradigms in production logistics - Intelligent conveyor system, Intelligent commissioning system, Intelligent production machine, Intelligent load carrier, Application-specific demand on Intelligent Objects (user-oriented functions), Technological realization of Intelligent Objects (product-oriented functions)	
Unit –IV	**08 Hrs**
Augmented Worker: Augmented and Virtual Reality, softwares, Industrial Applications – Maintenance, Assembly, Collaborative operations, Training **Digital-to-Physical:** Additive Manufacturing technologies, Advantages, impact on environment, Applications – Automotive, Aerospace, Electronics and Medical	
Unit –V	**07 Hrs**
Digital twin, Virtual factory, Total Productive Maintenance, Industry 4.0 case studies, Understanding I 4.0 in MSMEs, What's Next: Industry 5.0/Society 5.0	

Course Outcomes: After completing the course, the students will be able to:	
CO1	Identify the basic components of Industry 4.0
CO2	Analyse the role of Big data for modern manufacturing
CO3	Create AR/VR models for industrial scenario
CO4	Create simple Additive manufactured parts

Reference Books	
1.	Industry 4.0: Managing the Digital Transformation, Alp Ustundag, Emre Cevikcan, 2017, Springer, ISBN: 978-3-319-57869-9, ISBN: 978-3-319-57870-5
2.	The Concept Industry 4.0 - An Empirical Analysis of Technologies and Applications in Production Logistics, Christoph Jan Bartodziej, 2017, Springer Gabler, ISBN 978-3-658-16501-7 ISBN 978-3-658-16502-4
3.	**Industry 4.0 - The Industrial Internet of Things, Alasdair Gilchrist, 2016, APRESS, ISBN-13 978-1-4842-2046-7 ISBN-13: 978-1-4842-2047-4**
4.	Digitizing the Industry – Internet of Things connecting the Physical, Digital and Virtual Worlds, Ovidiu Vermesan, 2016, River Publishers, ISBN 978-87-93379-81-7 ISBN 978-87-93379-82-4

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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. **THE SUM OF TWO QUIZZES WILL BE THE FINAL QUIZ MARKS.**	**20**
2.	**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.**	**40**
3.	**EXPERIENTIAL LEARNING:** Students will be evaluated for their creativity and practical implementation of the problem. Case study-based teaching learning (10), Program specific requirements (10), Video based seminar/presentation/demonstration (20**) Phase 2 will be done in the exhibition mode (Demo/Prototype/any outcome). ADDING UPTO 40 MARKS**.	**40**
	MAXIMUM MARKS FOR THE CIE THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1: (Compulsory)	16
3 & 4	Unit 2: (Internal Choice)	16
5 & 6	Unit 3: (Internal Choice)	16
7 & 8	Unit 4: (Internal Choice)	16
9 & 10	Unit 5: (Internal Choice)	16
	TOTAL	**100**

Semester: VI						
INDUSTRIAL PSYCHOLOGY FOR ENGINEERS **Category: Institutional Elective (Group – F)** **(Theory)**						
Course Code	**:**	**21IE6F7**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45 L**		**SEE Duration**	**:**	**3 Hours**

Unit-I	**08 Hrs**
Introduction to Psychology: Definition and goals of Psychology: Role of a Psychologist in the Society: Today's Perspectives (Branches of psychology- Clinical, Industrial). Psychodynamic, Behavioristic, Cognitive, Humanistic, Psychological Research and Methods to study Human Behavior: Experimental, Observation, Questionnaire and Clinical Method.	
Unit – II	**08 Hrs**
Intelligence and Aptitude: Concept and definition of Intelligence and Aptitude, Nature of Intelligence. Theories of Intelligence – Spearman, Thurston, Guilford Vernon. Characteristics of Intelligence tests, Types of tests. Measurement of Intelligence and Aptitude, Concept of IQ, Measurement of Multiple Intelligence – Fluid and Crystallized Intelligence.	
Unit –III	**10 Hrs**
Personality: Concept and definition of personality, Approaches of personality- psychoanalytical, Socio- Cultural, Interpersonal and developmental, Humanistic, Behaviorist, Trait and type approaches. Assessment of Personality: Self- report measures of Personality, Questionnaires, Rating Scales and Projective techniques, its Characteristics, advantages & limitations, examples. Behavioral Assessment.	
Unit –IV	**10 Hrs**
Learning: Definition, Conditioning – Classical Conditioning, Basics of Classical Conditioning (Pavlov), the process of Extinction, Discrimination and Generalization. Operant Conditioning (Skinner expt). The basics of operant conditioning, Schedules of reinforcement. Cognitive – Social approaches to learning – Latent Learning, Observational Learning, Trial and Error Method, Insightful Learning.	
Unit –V	**09 Hrs**
Application of Psychology in Working Environment: The present scenario of information technology, the role of psychologist in the organization, Selection and Training of Psychology Professionals to work in the field of Information Technology. **Psychological Stress**: a. Stress- Definition, Symptoms of Stress, Extreme products of stress v s Burnout, Work Place Trauma. Causes of Stress – Job related causes of stress.Sources of Frustration, Stress and Job Performance, Stress Vulnerability-Stress threshold, perceived control. Type A and Type B.**Psychological Counseling** - Need for Counseling, Types – Directed, Non- Directed, Participative Counseling.	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Describe the basic theories, principles, and concepts of applied psychology as they relate to behaviors and mental processes.
CO2	Define learning and compare and contrast the factors that cognitive, behavioral, and Humanistic theorists believe influence the learning process.
CO3	Develop understanding of psychological attributes such as intelligence, aptitude, creativity, resulting in their enhancement and apply effective strategies for self-management and self-improvement.
CO4	Apply the theories into their own and others' lives in order to better understand their personalities and experiences.
CO5	Understand the application of psychology in engineering and technology and develop a route to accomplish goals in their work environment.

Reference Books	
1.	Understanding Psychology Feldman R. S, IV Edition, (1996) McGraw Hill India
2.	Psychology Robert A. Baron, III Edition (1995) Prentice Hall India.
3.	Organizational Behaviour , Stephen P Robbins Pearson Education Publications, 13th Edition, ISBN – 81-317 – 1132 – 3
4.	Organisational Behaviour : Human Behaviour at Work ,John W.Newstrem and Keith Davis. Tata McGraw Hill India, 10th Edition, ISBN 0-07-046504-5
5	Psychology-themes and variations , Wayne Weiten, IV Edition, Brooks / Cole Publishing Co.

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
ELEMENTS OF FINANCIAL MANAGEMENT **Category: Institutional Elective (Group – F)** **(Theory)**						
Course Code	**:**	**21IE6F8**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45 Hrs**		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**06 Hrs**
Financial Management-An overview: Financial Decisions in a firm, Goals of a firm, Fundamental principle of finance, Organization of finance function and its relation to other functions, Regulatory framework. **The financial System:** Functions, Assets, Markets, Market returns, Intermediaries, regulatory framework, Growth and trends in Indian financial system. **Financial statements, Taxes and cash flow:** Balance sheet, statement of profit and loss, items in annual report, manipulation of bottom line, Profits vs Cash flows, Taxes. **(Conceptual treatment only)**	
Unit – II	**10 Hrs**
Time Value of Money: Future value of a single amount, future value of an annuity, present value of a single amount, present value of an annuity. **Valuation of securities:** Basic valuation model, bond valuation, equity valuation-dividend capitalization approach and other approaches. **Risk and Return:** Risk and Return of single assets and portfolios, measurement of market risk, relationship between risk and return, implications **(Conceptual and Numerical treatment)**	
Unit –III	**10 Hrs**
Techniques of Capital Budgeting: Capital budgeting process, project classification, investment criteria, Net present value, Benefit-Cost ratio, Internal Rate of return, Payback period, Accounting rate of return. **Cost of Capital:** Preliminaries Cost of debt and preference, cost of retained earnings, cost of external equity, determining the proportions, weighted average cost of capital, weighted marginal cost of capital schedule. **Capital structure and cost of capital:** Assumptions and concepts, net income approach, net operating income approach, traditional position, Modigliani and Miller Position, Taxation and Capital structure, Other imperfections and Capital structure **(Conceptual and Numerical treatment)**	
Unit –IV	**10 Hrs**
Long term finance: Sources- Equity capital, Internal accruals, preference capital, term loans, debentures. Raising long term finance- Venture capital, Initial Public Offer, Follow on Public Offer, Rights Issue, Private Placement, Term Loans, Investment Banking **Securities Market:** Primary market vs Secondary market, Trading and Settlements, Stock market quotations and Indices, Govt. securities market, Corporate debt market. **Working Capital – Policy and Financing:** Factors influencing working capital requirements, Current assets financing policy, operating cycle and cash cycle. Accruals, trade credit, banks, public deposits, inter-corporate deposits, short term loans, right debentures, commercial paper, Factoring **(Conceptual treatment only)**	
Unit –V	**09 Hrs**
Contemporary topics in Finance: Reasons and Mechanics of a merger, Takeovers, Divestures, Demergers, World monetary system, Foreign exchange markets, raising foreign currency finance, International capital budgeting, Options market, Futures market, Warrants, Venture capital financing framework, Indian venture capital scenario. (Conceptual treatment only)	

Course Outcomes: After completing the course, the students will be able to:-	
CO1	Explain the features of financial system and basic principles of financial management.
CO2	Describe the processes and techniques of capital budgeting and theories of capital structure.
CO3	Demonstrate an understanding of various sources of long term and working capital financing by organizations.
CO4	Analyze the trends in global financial scenarios.

Reference Books:	
1.	Fundamentals of Financial Management, Prasanna Chandra, 6th Edition, 2018, McGraw Hill
2.	Education(India) Pvt. Ltd, ISBN: 978-93-392-0313-9, 93-392-0313-5
3.	Financial Management-Text, Problems and Cases, Khan M Y & Jain P K, 8th Edition, 2018,
4.	McGraw Hill Education(India) Pvt. Ltd, ISBN: 9353162181 , 9789353162184

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	**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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only; wherein one sub division will be a caselet in the related topics)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI						
UNIVERSAL HUMAN VALUES – II **Category: Institutional Elective (Group – F)** **(Theory)**						
Course Code	**:**	**21IE6F9**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**42L**		**SEE Duration**	**:**	**3.00 Hours**

Unit-I	**10 Hrs**
Introduction-Basic Human Aspiration, its fulfillment through All-encompassing Resolution. The basic human aspirations and their fulfillment through Right understanding and Resolution, Right understanding and Resolution are the activities of the Self, Self is central to Human Existence; All-encompassing Resolution for a Human Being, its details and solution of problems in the light of Resolution.	
Unit – II	**10 Hrs**
Right Understanding (Knowing)- Knower, Known & the Process. The domain of right understanding starts from understanding the human being (the knower, the experiencer and the doer); and extends up to understanding nature/existence – its interconnectedness and co-existence; and finally understanding the role of human being in existence (human conduct).	
Unit –III	**08 Hrs**
Understanding Existence (including Nature). A comprehensive understanding (knowledge) about the existence, which certainly includes the Nature. The need and the process of inner evolution (through self-exploration, self-awareness and self-evaluation)- particularly awakening to activities of the Self: Realization, Understanding and Contemplation in the Self (Realization of Co-Existence, Understanding of Harmony in Nature and Contemplation of Participation of Human in this harmony/ order leading to comprehensive knowledge about the existence).	
Unit –IV	**08 Hrs**
Understanding Human Being. Understanding the human being comprehensively is the first step and the core theme of this course; human being as co-existence of the self and the body, the activities and potentialities of the self, Reasons for harmony/contradiction in the self.	
Unit –V	**08 Hrs**
Understanding Human Conduct, All-encompassing Resolution & Holistic Way of Living. Understanding Human Conduct, Understanding different aspects of All-encompassing Resolution (understanding, wisdom, science etc.), Holistic way of living for Human Being with All-encompassing Resolution covering all four dimensions of human endeavour viz., realization, thought, behavior and work (participation in the larger order) leading to harmony at all levels from self to Nature and entire Existence.	

Course Outcomes: After completion of the course the students will be able to	
CO1	Understand the basic human aspiration with program of its fulfilment and meaning of resolution in the complete expanse of human living.
CO2	Understand human being in depth and see how self is central to human being
CO3	Understand existence in depth and see how coexistence is central to existence
CO4	Understand human conduct and the holistic way of living leading to human tradition

Reference Books	
1	A foundation course in human values and professional ethics, R. R. Gaur, R Asthana, G P Bagaria, 2nd revised Edition, excel books, New Delhi – 2019, ISN 978-93-87034-47-1
2	Avartansheel Arthshastra, A Nagraj, Divya Path Sansthan, Amarkantak, India, ISBN 978-8-174-46781-2
3	Economy of Performance- a quest for social order based on non – violence, J C Kumarappa, 2010, Sarva-Seva-Sangh-Prakashan, Varanasi, India
4	Energy and Equity, Ivan Illich, 1974, The Trinity Press, Worcester & Harper Collins, USA, ISBN, 0060803274, 9780060803278

RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	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 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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

Semester: VI

Human Machine Interface (HMI)

Category: Institutional Elective (Group – F)

Industry Assisted Elective-BOSCH

(Theory)

Course Code	**:**	**21IE6F10**		**CIE**	**:**	100 Marks
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	100 Marks
Total Hours	**:**	**45L**		**SEE Duration**	**:**	3Hours

Unit-I — **09 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 — **09 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 — **09 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 — **09 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 — **09 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.

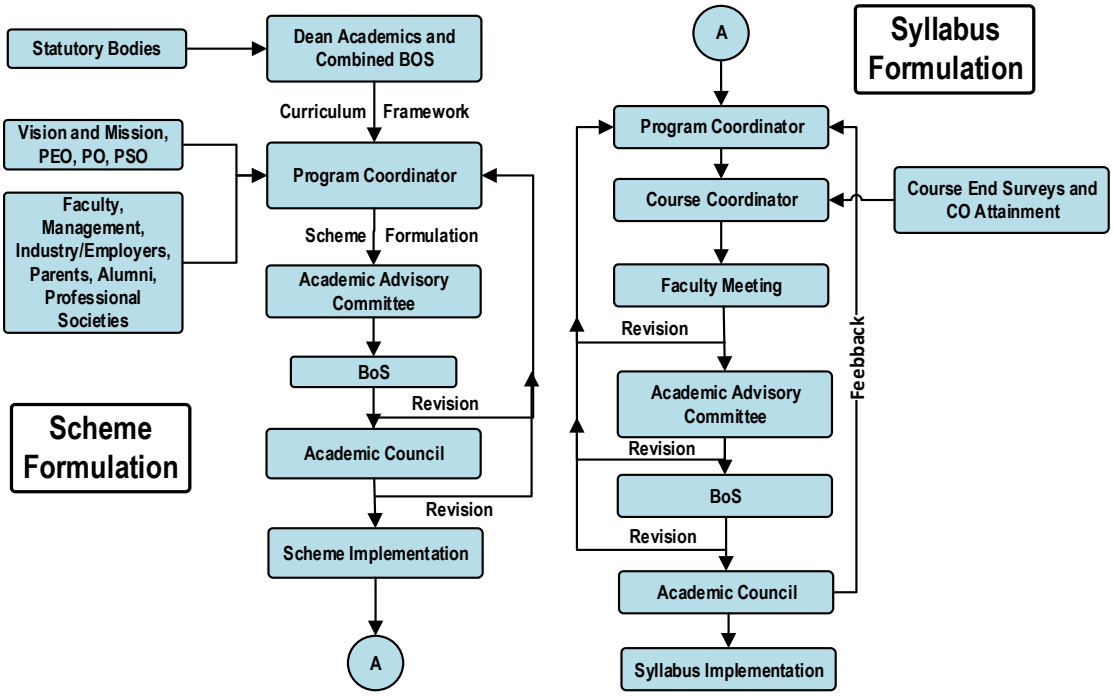
Course Outcomes: After completing the course, the students will be able to:-	
CO1	Understanding the application of HMIs in various domain
CO2	Comparison of various communication protocols used in HMI development.
CO3	Apply and Analyse the car multimedia system free software and hardware evolution
CO4	Design and Evaluate the graphic tools and advanced techniques for creating car dashboard multimedia systems

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

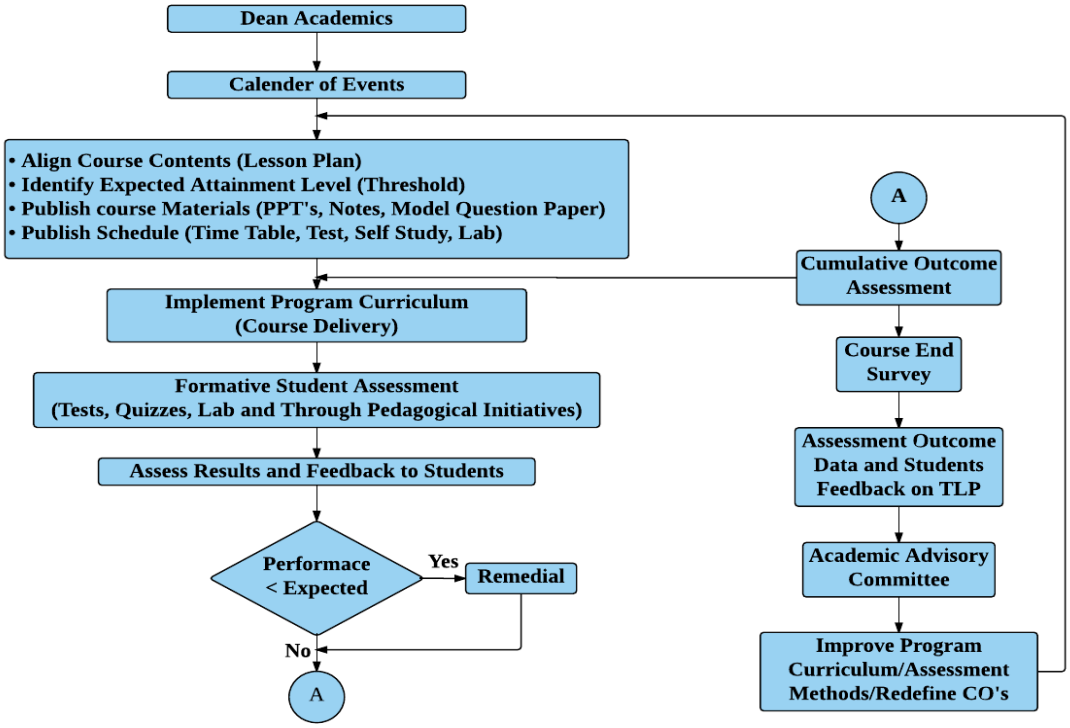
RUBRIC FOR THE CONTINUOUS INTERNAL EVALUATION (THEORY)		
#	COMPONENTS	MARKS
1.	**QUIZZES:** Quizzes will be conducted in online/offline mode. **TWO QUIZZES** will be conducted & Each Quiz will be evaluated for 10 Marks adding up to 20 Marks. **THE SUM OF TWO QUIZZES WILL BE CONSIDERED AS FINAL QUIZ MARKS.**	**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 THEORY	**100**

RUBRIC FOR SEMESTER END EXAMINATION (THEORY)		
Q. NO.	**CONTENTS**	**MARKS**
	PART A	
1	Objective type questions covering entire syllabus	20
	PART B (Maximum of TWO Sub-divisions only)	
2	Unit 1 : (Compulsory)	16
3 & 4	Unit 2 : Question 3 or 4	16
5 & 6	Unit 3 : Question 5 or 6	16
7 & 8	Unit 4 : Question 7 or 8	16
9 & 10	Unit 5: Question 9 or 10	16
	TOTAL	**100**

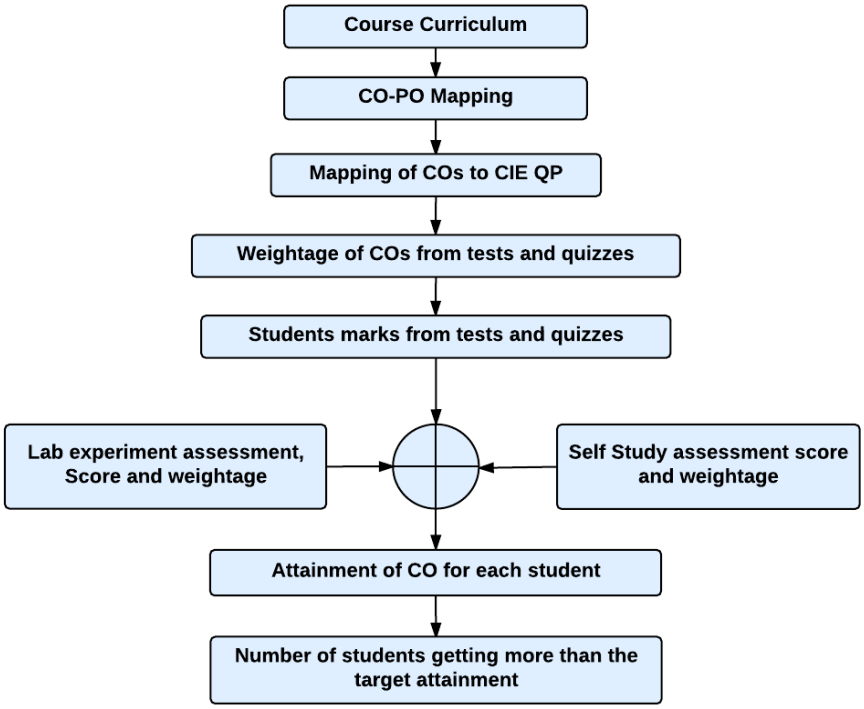
Curriculum Design Process



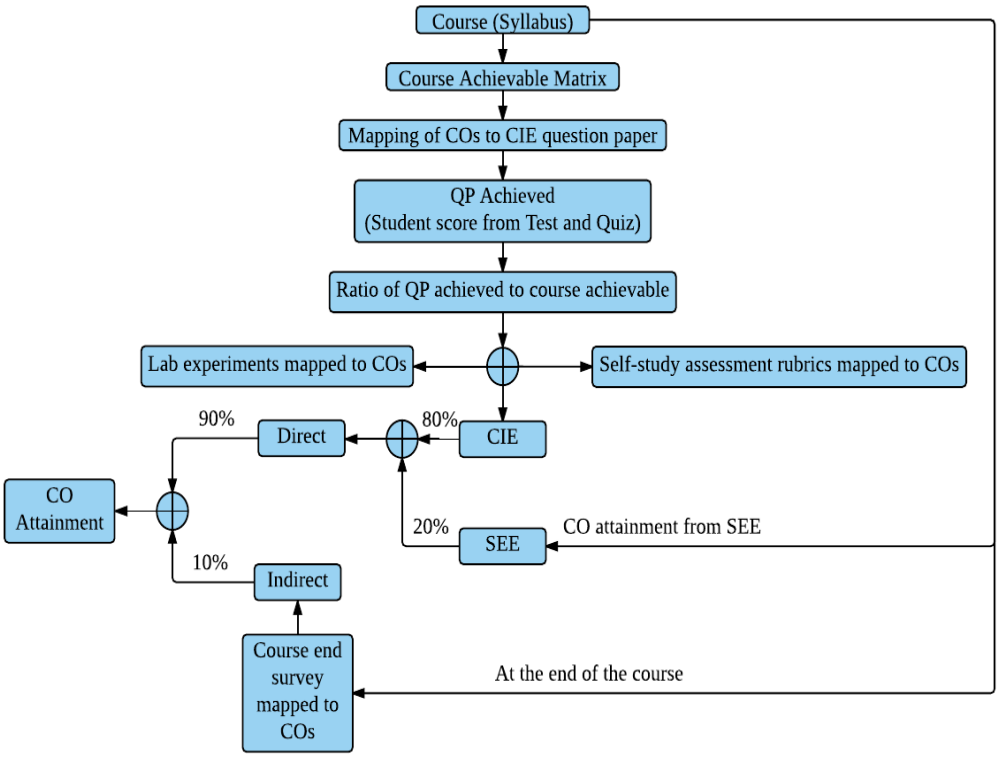
Academic Planning and Implementation



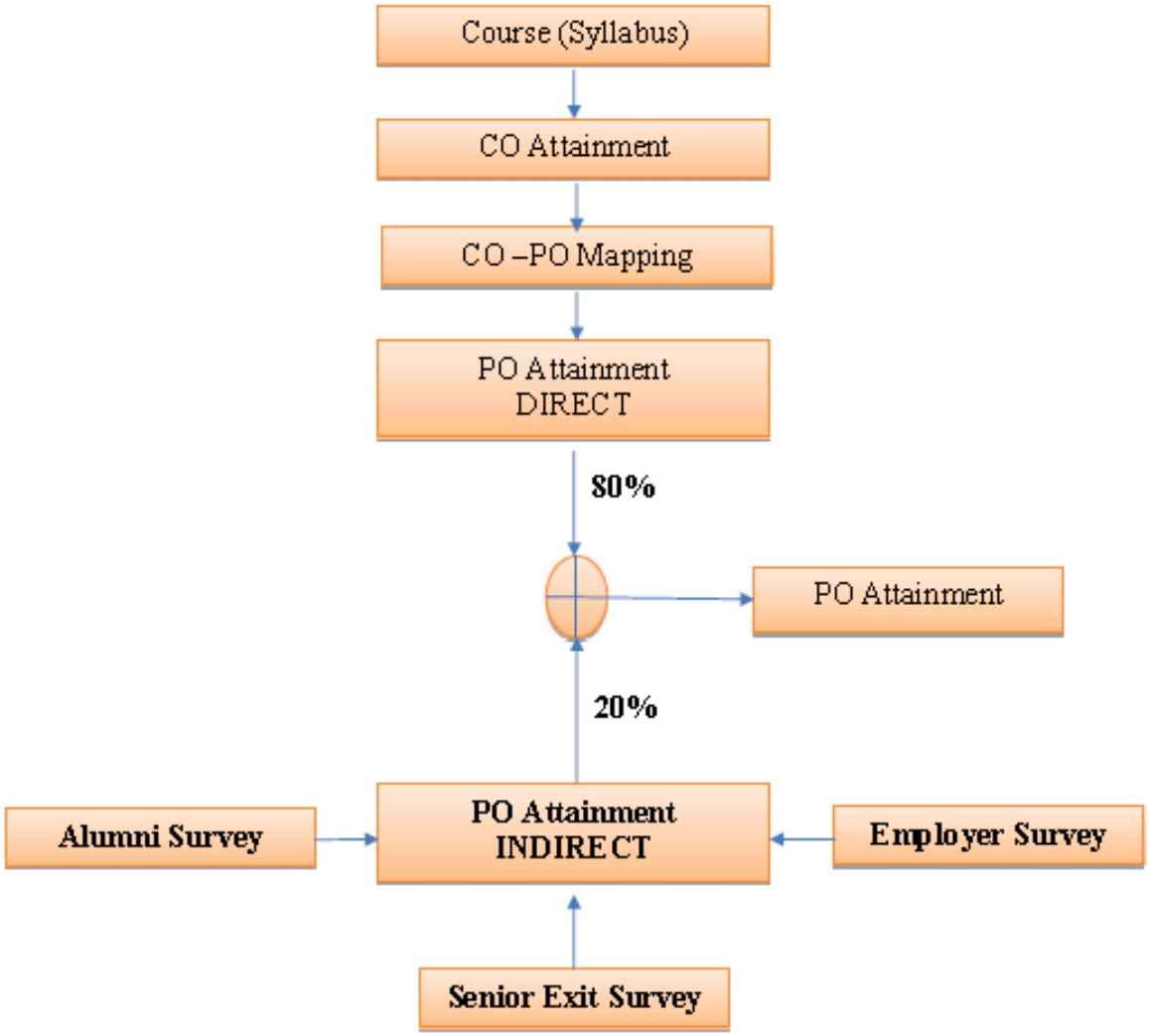
Process For Course Outcome Attainment



Final CO Attainment Process


Course (Syllabus)
Course Achievable Matrix
Mapping of COs to CIE question paper
QP Achieved
(Student score from Test and Quiz)
Ratio of QP achieved to course achievable
Lab experiments mapped to COs
Self-study assessment rubrics mapped to COs
90%
Direct
80%
CIE
CO
Attainment
20%
SEE
CO attainment from SEE
10%
Indirect
Course end
survey
mapped to
COs
At the end of the course

Program Outcome Attainment Process



INNER BACK COVER PAGE

PROGRAM OUTCOMES (POs)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling to complex engineering activities, with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.