R.V.COLLEGE OF ENGINEERING

(Autonomous Institution Affiliated to VTU, Belagavi)

R.V. Vidyaniketan Post, Mysore Road

Bengaluru – 560 059

Bachelor of Engineering (B.E.)

Scheme and Syllabus for V & VI Semesters

2016 SCHEME

BIOTECHNOLOGY

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 ethically 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 principles, develop oral and written communication skills and team work that prepare them for a successful career in Biotechnology and allied industries.

PEO2: Function at a technically competent level in formulating and solving problems in Biotechnology and to develop an outlook for higher education and lifelong learning.

PEO3: Organize and utilize the knowledge to develop biological processes and products, exhibit professionalism, ethical attitude to become an entrepreneur.

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.

Lead Society: American Society of Agricultural and Biological Engineers

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2016 SCHEME

BIOTECHNOLOGY

ABBREVIATIONS

Sl. No.	ABBREVIATION	MEANING
1	VTU	Visvesvaraya Technological University
2	BS	Basic Sciences
3	BT	Biotechnology
4	CIE	Continuous Internal Evaluation
5	CS	Computer Science and Engineering
6	CV	Civil Engineering
7	CHY	Chemistry
8	EC	Electronics and Communication Engineering
9	EE	Electrical and Electronics Engineering
10	ES	Engineering Science
11	HSS	Humanities and Social Sciences
12	ME	Mechanical Engineering
13	PHY	Engineering Physics
14	SEE	Semester End Examination
15	MAT	Engineering Mathematics
16	PCE	Professional Core Elective
17	GE	Global Elective

INDEX

R V COLLEGE OF ENGINEERNG, BENGALURU-560 059
(Autonomous Institution Affiliated to VTU, Belagavi)

DEPARTMENT OF BIOTECHNOLOGY

FIFTH SEMESTER CREDIT SCHEME								
Sl. No.	**Course Code**	**Course Title**	**BOS**	**Credit Allocation**				**Total Credits**
				L	**T**	**P**	**S**	
1.	16HEM51	Foundations of Management & Economics	HSS	2	0	0	0	2
2.	16BT52	Bioinformatics	BT	3	0	1	1	5
3.	16BT53	Genetic Engineering	BT	3	0	1	1	5
4.	16BT54	Reaction Engineering	BT	3	1	0	0	4
5.	16BT55	Immunotechnology	BT	3	0	0	0	3
6.	16BT5AX	Elective A (PE)	BT	3	0	0	1	4
7.	16G5BXX	Elective B (GE)	Respective BoS	4	0	0	0	4
Total number of Credits				**21**	**01**	**02**	**03**	**27**
Total Number of Hours / Week				**21**	**02**	**04**	**12****	**27**

SIXTH SEMESTER CREDIT SCHEME								
Sl. No.	**Course Code**	**Course Title**	**BOS**	**Credit Allocation**				**Total Credits**
				L	**T**	**P**	**S**	
1.	16HSI61	Intellectual Property Rights and Entrepreneurship	HSS	3	0	0	0	3
2.	16BT62	Microbial Biotechnology	BT	3	0	1	1	5
3.	16BT63	Process Dynamics & Control	BT/CH	3	0	1	1	5
4.	16BT64	Genomics & Proteomics	BT	3	1	0	0	4
5.	16BT6CX	Elective C (PE)	BT	3	0	0	1	4
6.	16BT6DX	Elective D (PE)	BT	4	0	0	0	4
7.	16G6EXX	Elective E (GE)	Respective BoS	3	0	0	0	3
8.	16HS68	Professional Practice III (Employability skills & Professional Development of Engineers)	HSS	0	0	1	0	1
Total number of Credits				**23**	**01**	**02**	**03**	**29**
Total Number of Hours / Week				**23**	**02**	**04**	**12****	**29**

** Non-contact hours

V Sem		
GROUP A: PROFESSIONAL CORE ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	16BT5A1	Pharmaceuticals
2.	16BT5A2	Agricultural Biotechnology
3.	16BT5A3	Process Engineering
4.	16BT5A4	Data Structure

GROUP B: GLOBAL ELECTIVES				
Sl. No.	**Host Dept.**	**Course Code**	**Course Title**	**Credits**
1.	BT	16G5B01	Bioinformatics	4
2.	CH	16G5B02	Fuel Cell Technology	4
3.	CV	16G5B03	Geoinformatics	4
4.	CSE	16G5B04	Graph Theory	4
5.	ECE	16G5B05	Artificial Neural Networks & Deep Learning	4
6.	EEE	16G5B06	Hybrid Electric Vehicles	4
7.	IEM	16G5B07	Optimization Techniques	4
8.	E&I	16G5B08	Sensors & Applications	4
9.	ISE	16G5B09	Introduction To Management Information Systems	4
10.	ME	16G5B10	Industrial Automation	4
11.	TCE	16G5B11	Telecommunication Systems	4
12.	MAT	16G5B12	Computational Advanced Numerical Methods	4
13.	AE	16G5B13	Basics of Aerospace Engineering	4

VI Sem		
GROUP C: PROFESSIONAL CORE ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	16BT6C1	Clinical Technology
2.	16BT6C2	Food Engineering
3.	16BT6C3	Fermentation Technology
4.	16BT6C4	Java and J2EE
GROUP D: PROFESSIONAL CORE ELECTIVES		
1.	16BT6D1	Medical Instrumentation
2.	16BT6D2	Food & Diary Biotechnology
3.	16BT6D3	Plant Design & Economics
4.	16BT6D4	Systems Biology

GROUP E: GLOBAL ELECTIVES				
Sl. No.	**Host Dept.**	**Course Code**	**Course Title**	**Credits**
1.	BT	16G6E01	Bioinspired Engineering	3
2.	CH	16G6E02	Green Technology	3
3.	CV	16G6E03	Solid Waste Management	3
4.	CSE	16G6E04	Introduction to Web Programming	3
5.	ECE	16G6E05	Automotive Electronics	3
6.	EEE	16G6E06	Industrial Electronics	3
7.	IEM	16G6E07	Project Management	3
8.	E&I	16G6E08	Virtual Instrumentation	3
9.	ISE	16G6E09	Introduction to Mobile Application Development	3
10.	ME	16G6E10	Automotive Engineering	3
11.	TCE	16G6E11	Mobile Network System and Standards	3
12.	MAT	16G6E12	Applied Partial Differential Equations	3
13.	AE	16G6E13	Aircraft Systems	3

V SEMESTER FOUNDATIONS OF MANAGEMENT AND ECONOMICS (Theory) (Common to BT, CHE, CV, E&I, IEM, ME)		
Course Code: 16HEM51		**CIE Marks: 50**
Credits: L:T:P:S: 2:0:0:0		**SEE Marks: 50**
Hours: 23L		**SEE Duration: 02Hrs**
Course Learning Objectives: The students will be able to		
1	Understand the evolution of management thought.	
2	Acquire knowledge of the functions of Management.	
3	Gain basic knowledge of essentials of Micro economics and Macroeconomics.	
4	Understand the concepts of macroeconomics relevant to different organizational contexts.	

UNIT-I	
Introduction to Management: Management Functions, Roles & Skills, Management History – Classical Approach: Scientific Management & Administrative Theory, Quantitative Approach: Operations Research, Behavioural Approach: Hawthorne Studies, Contemporary Approach: Systems & Contingency Theory.	**04 Hrs**
UNIT-II	
Foundations of Planning: Types of Goals & Plans, Approaches to Setting Goals & Plans, Strategic Management Process, Corporate & Competitive Strategies.	**02 Hrs**
Organizational Structure & Design: Overview of Designing Organizational Structure: Work Specialization, Departmentalization, Chain of Command, Span of Control, Centralization & Decentralization, Formalization, Mechanistic & Organic Structures.	**03 Hrs**
UNIT-III	
Motivating Employees: 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 & Vroom's Expectancy Theory.	**03 Hrs**
Managers as Leaders: Behavioural Theories: Ohio State & University of Michigan Studies, Blake & Mouton's Managerial Grid, Contingency Theories of Leadership: Hersey & Blanchard's Situational Leadership, Contemporary Views of Leadership: Transactional & Transformational Leadership.	**03 Hrs**
UNIT-IV	
Introduction to Economics: Concept of Economy and its working, basic problems of an Economy, Market mechanism to solve economic problems, Government and the economy, **Essentials of Micro Economics:** Concept and scope, tools of Microeconomics, themes of microeconomics, Decisions: some central themes, Markets: Some central themes, Uses of Microeconomics.	**04 Hrs**
UNIT-V	
Essentials of Macroeconomics: Prices and inflation, Exchange rate, Gross domestic product(GDP) , components of GDP, the Labour Market, Money and banks, Interest rate, Macroeconomic models- an overview, Growth theory, The classical model, Keynesian cross model, IS-LM-model, The AS-AD-model, The complete Keynesian model, The neo-classical synthesis, Exchange rate determination and the Mundell-	**04 Hrs**

Fleming model	
Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain 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:	Select & Implement the right leadership practices in organizations that would enable systems orientation.
CO4:	Understand the basic concepts and principles of Micro economics and Macroeconomics

Reference Books	
1.	Management, Stephen Robbins, Mary Coulter & Neharika Vohra, 10th Edition, 2001, Pearson Education Publications, ISBN: 978-81-317-2720-1.
2.	Management, James Stoner, Edward Freeman & Daniel Gilbert Jr, 6th Edition, 1999, PHI, ISBN: 81-203-0981-2.
3.	Microeconomics, Douglas Bernheim B & Michael D Whinston, 5th Edition, 2009, TMH Pub. Co. Ltd, ISBN: 13:978-0-07-008056-0.
4.	Macroeconomics: Theory and Policy, Dwivedi.D.N, 3rd Edition, 2010, McGraw Hill Education; ISBN-13: 978-0070091450.
5.	Essentials of Macroeconomics, (www.bookboon.com), Peter Jochumzen, 1st Edition. 2010, e-book, ISBN:978-87-7681-558-5.

Continuous Internal Evaluation (CIE); Theory (50 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 05 marks adding up to 15 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 25 marks each and the sum of the marks scored from three tests is reduced to 30. The marks component for Assignment is 05. The total marks of CIE are 50.

Semester End Evaluation (SEE); Theory (50 Marks)

SEE for 50 marks are executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 10 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 08 marks adding up to 40 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2	1		2	2			1			2	2	
CO3	1							2	2	2	1	
CO4	1	2				2						2

Low-1 Medium-2 High-3

Semester: V		
BIOINFORMATICS (Theory and practice)		
Course Code: 16BT52		**CIE Marks: 150**
Credits: L:T:P:S: 3:0:1:1		**SEE Marks: 150**
Hours: 36L		**SEE Duration: 3 Hrs**
		SEE Duration(Laboratory) : 3 Hrs

Course Learning Objectives:	
1	Acquire the knowledge of Biological database and its role in *insilico* research
2	Understand the essential algorithms behind the biological data analysis such as Dynamic programming, Dot plotting, Evolutionary and Clustering algorithms along with their implementation.
3	Use various tools and techniques for the prediction of linear & non-linear structures of both macro and micro molecules and study the dynamics of macromolecules and High Throughput Virtual Studies.
4	Perform annotation of unknown DNA and Protein sequences and explore the principles of molecular modeling and *insilico* drug design

Unit-I	
Overview of bioinformatics and Biological Databases: Introduction to Bioinformatics, Goals, Scope, applications in biological science and medicine. **Biological databases:** Types of Sequence Databases - The nucleotide and protein sequence databases, Primary and secondary databases. Structure Databases - PDB and MMDB records, molecular modeling databases at NCBI. Special Databases - Genome, Microarray, metabolic pathway, domain databases. Sequence retrieval from the databases.	**07 Hrs**
Unit – II	
Sequence analysis: Significance of **s**equence alignment methods, homology, similarity and identity patterns. Scoring matrices: BLOSSUM (BLOSSUM40, BLOSSUM60, and BLOSSUM90), PAM (PAM120 and PAM250). Sequence alignment algorithms: Dot matrix, Dynamic programming and progressive alignment. Types of alignment: Global, Local, Pair wise & Multiple Sequence alignment, FASTA & BLAST for database searches. **Phylogenetic analysis:** Introduction to cladogram and phylogram, rooted and unrooted phylogenetic trees. Phylogenetic data analysis: building the data model (Multiple sequence alignment). Determining the substitution model. Phylogenetic tree building Methods. Methods of tree evaluation.	**07 Hrs**
Unit -III	
Predictive and structural bioinformatics: Gene prediction programs – ab initio and homology based approaches. ORFs and HMM for gene prediction. Detection of functional sites and codon bias in the DNA. Predicting RNA secondary structure, Protein structure basics, structure visualization, comparison and classification. Protein structure predictive methods using protein sequence, Protein identity based on composition. Structure prediction - Prediction of secondary structure, Folding classes and Tertiary structures. Primers and Restriction mapping.	**08 Hrs**
Unit –IV	
Genome analysis: Genome mapping - sequencing, sequence assembly, annotation, comparative genomics. Functional genomics – sequence based approach, microarray based approach, comparison of SAGE and Microarray. Prediction of gene function based on composition. Computational analysis of alternative splicing and Human genetic linkage analysis. Expressed Sequence Tags: clustering and analysis.	**07 Hrs**
Unit –V	
Introduction to Molecular modeling and Drug designing: Introduction to molecular modeling, methods of molecular modeling. Drug designing process - deriving pharmacophore pattern, receptor mapping, estimating biological activities, ligand-receptor	**07 Hrs**

interactions and molecular docking. Drug designing methods such as Rational drug designing and QSAR	
LABORATORY EXPERIMENTS	
1. Sequence retrieval from nucleic acid and protein databases and retrieving articles from PubMed. 2. Locating the chromosome of a Gene 3. Retrieving structural data of a protein using PDB database and Motif Information of a Protein Using Prosite 4. Visualization of the structure of a protein and finding the distance between the ligands and the amino acids. 5. Finding ORF of a Given Sequence. 6. Restriction mapping and Primer design 7. Global and local alignments. 8. Pairwise Sequence Alignment using BLAST and Multiple sequence alignment using CLUSTAL W. 9. Phylogenetic Analysis using PHYLIP - Rooted trees and unrooted trees. 10. Secondary structure analysis of a protein using SOPMA. 11. Retrieval of the attributes of a drug molecule, and converting chemical file formats. 12. Homology modeling using modeler. 13. Protein ligand interaction studies.	
Note: Each student has to perform 13 experiments in a semester. 10 Experiments are GUIDED experiments, 03 Experiments involving experiential learning.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Demonstrate the knowledge of retrieval of the biological data in the essential formats and its analysis.
CO2:	Analyse the gene, protein and RNA data to find the degree of similarities and identifying the patterns
CO3:	Apply the drug designing methods for screening and inventing the new targets and drugs
CO4:	Predict the structure of a compound and design the molecule.

Reference Books	
1	Jin Xiong, Essential Bioinformatics, 2006, Cambridge University Press, ISBN: 9780521600828, Units III & IV
2	D.Andreas Baxevanis and B. F; Francis Ouellette. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins; Wiley-IEEE; 3rd edn; 2009; ISBN: 9788126521920; Units I & II
3	D W Mount; Bioinformatics: Sequence and Genome Analysis; CSHL Press; 2nd edn;2004; ISBN: 9780879697129 Units I & IV
4	A Kriete and R Eils; Computational Systems Biology; Academic Press; illustrated edn; 2006; ISBN: 9780120887866; Unit V.

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Theory – 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total CIE for theory is 100.

Laboratory- 50 Marks

The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150

Theory – 100 Marks

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	1	-	1	-	2	2	1	1	-	-	2
CO2	2	2	-	2	2	1	-	-	1	-	-	1
CO3	2	2	1	2	-	2	2	-	1	-	-	2
CO4	2	2	1	3	-	2	-	-	-	-	-	1

High-3: Medium-2: Low-1

Semester: V		
GENETIC ENGINEERING (Theory and practice)		
Course Code:16BT53		**CIE Marks: 150**
Credits: L:T:P:S: 3:0:1:1		**SEE Marks: 150**
Hours: 35L		**SEE Duration: 3Hrs**
		SEE Duration (Laboratory) : 3 Hrs

Course Learning Objectives:	
1	Identify and solve initial value problems, physically interpret the solution, using Laplace Transforms and Inverse Laplace transforms.
2	Evaluate extremal of integrals involving functionals with applications to physical situations.
3	Understand the basics of Matrix theory, Eigen values and Eigen vectors, its applications for finding solution of system of linear equations.
4	Analyse the given set of experimental data and fit suitable approximating curves.

Unit-I	
Introduction to Genetic Engineering: Role of genes within cells, genetic elements that control gene expression, scope and applications of genetic engineering, Isolation and purification of genomic, plasmid DNA and mRNA. Method of creating recombinant DNA molecules.	**07 Hrs**
Unit – II	
Tools used in Genetic Engineering: Vectors: Types, biology and salient features of vectors in recombinant DNA technology: Plasmids, Phages, Cosmids, Phagemids, and Artificial chromosomes. **Enzymes:** Types and classification: Nucleases, ligases, polymerases, topoisomerases, modifying enzymes, DNase, linkers and adaptors.	**07 Hrs**
Unit -III	
Gene transfer techniques: Biological, chemical and physical methods. **Transformation** – Methods, Preparation of competent cells, Introduction of DNA into host cells techniques used for selection, screening and characterization of transformants: Introduction, selectable marker genes, reporter genes, screening of clones, nucleic acid blotting and hybridization..	**07 Hrs**
Unit –IV	
Construction and screening of DNA libraries, Polymerase chain reaction: Construction of genomic and cDNA libraries. Screening of DNA libraries for clone identification. Characterization of clones. Polymerase chain reaction (PCR) - techniques and requirements, types of PCR, applications. Blotting techniques (Southern, Northern), Radioactive and non-radioactive labeling of nucleic acids.	**07 Hrs**
Unit –V	
Applications and advance genome editing: Transgenic science in plant and animal improvement, Biopharming- Animals as bioreactor for recombinant protein, Antisense technology. Genome editing- (Zinc finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), CRISPR technology.	**07 Hrs**

LABORATORY EXPERIMENTS

1. Isolation of plasmid DNA from E. coli
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 / genomic DNA
6. Preparation of competent cells (E.coli / Agrobacterium)
7. Genetic transformation of E.coli
8. Screening techniques to select recombinants
9. Polymerase Chain Reaction (PCR)
10. Separation of Proteins - SDS-PAGE

11. Agglutination Technique: Blood group identification 12. Ouchterlony Double Diffusion (ODD) 13. Rocket immune electrophoresis (RIEP) 14. Enzyme Linked Immunosorbent Assay (ELISA). **Note: Each student has to perform 12 experiments in a semester. 1 experiment to be conducted as self study experiment.**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand and explain the concepts of recombinant DNA technology
CO2:	Explain the manipulation, expression and regulation of genes
CO3:	Explain the current applications and advances of biotechnology and describe the steps involved in the production of biopharmaceuticals in microbial systems
CO4:	Analyze a research problem and design clear, step-by-step instructions for conducting experiments or testing hypothesis

Reference Books	
1	Gene Cloning and DNA Analysis – An Introduction, T.A.Brown, 6th Edition, 2010, Wiley-Blackwell Science, ISBN-13: 978-1405181730, ISBN-10: 9781405181730
2	Principles of gene manipulation, S.B. Primrose, R. M Twyman and R. W. Old, 7th Edition,2006, Blackwell, ISBN-10: 1405135441, ISBN-13: 978-1405135443
3	Molecular Biology of the cell, B.Alberts, A.Johnson, J.Lewis M.Raff, K.Robert and P. Walter, 5th Edition, 2008, Garland Science,ISBN-13: 978-0815341055, ISBN-10: 0815341059
4	Molecular Biotechnology – Principles and applications of recombinant DNA, B.R. Glick, J.J. Pasternak and C.L Patten, 4th Edition, 2010, ASM Press; ISBN-10: 1555814980,

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Theory – 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total CIE for theory is 100.

Laboratory- 50 Marks

The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150

Theory – 100 Marks

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	2	2	-	-	-	-	-	1	-	2
CO2	3	2	2	2	-	-	-	-	-	2	-	2
CO3	2	2	3	2	-	-	-	-	-	-	-	2
CO4	3	3	3	3	2	-	-	**2**	2	3	-	3

High-3: Medium-2: Low-1

Semester: V		
REACTION ENGINEERING (Theory)		
Course Code: 16BT54		**CIE Marks: 100**
Credits: L:T:P:S: 3:1:0:0		**SEE Marks: 100**
Hours: 36L+24T		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Develop the ability to analyse kinetic data and determine rate laws.
2	Explore the performance of reactors with multiple reactions.
3	Understand the non-ideal flow conditions in reactors ,to develop the skill to utilize simple models to characterize the performance of such reactors
4	Learn the stoichiometry of cell growth and product formation and determine stoichiometric and yield coefficients

Unit-I	
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). Analysis of 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.	**08 Hrs**
Unit – II	
Design of ideal reactors: Concept of ideality, development of design expressions for batch, tubular and stirred tank reactors for both constant and variable volume systems. Evaluation of rate equations, comparison of ideal reactors, multiple reactor system, numerical.	**08 Hrs**
Unit –III	
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..	**07 Hrs**
Unit –IV	
Kinetics of microbial growth and product formation: Phases of cell growth in batch cultures, simple unstructured kinetic models for microbial growth: Monod model, growth of filamentous organisms. Growth associated and non growth associated product formation kinetics, Leudeking – Piret models, substrate and product inhibition on cell growth and product formation, numerical.	**06 Hrs**
Unit –V	
Metabolic Stoichiometry and energetics: Stoichiometry of cell growth and product formation – elemental balances, degrees of reduction of substrate and biomass, available electron balances, yield coefficients of biomass and product formation, maintenance coefficients. Energetic analysis of microbial growth and product formation, oxygen consumption and heat evolution in aerobic cultures, thermodynamic efficiency of growth. Numerical**.**	**07 Hrs**

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:	Analyze the RTD data, plot C,E,F curves and determine mean residence time, variance, skewness and conversion for ideal and real reactors
CO4:	Evaluate the stoichiometric coefficients, yield coefficients, respiratory and maintenance coefficients for problems of microbial growth

Reference Books	
1	Octave Levenspiel; Chemical Reaction Engineering; John Wiley and Sons; 3rd edition; 3rd ed; 1999. ISBN: 0-471-25424-X
2	M.Shuler and F. Kargi; Bioprocess Engineering: Basic Concepts; Prentice Hall; 2nd ed; 2002. ISBN:0130819085
3	H.S Fogler; Elements of Chemical Reaction Engineering; Prentice Hall; 4th ed; 2006. ISBN:0130473944
4	P.M. Doran; Bioprocess Engineering Principles; Academic Press; 2nded; 2012. ISBN:978012220851

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	1	1	1	1	-	-	-	-	-	-	2
CO2	1	3	3	2	1	-	-	-	2	-	-	2
CO3	1	2	1	2	1	-	-	-	2	-	-	2
CO4	1	2	1	1	1	-	-	-	-	-	-	2

High-3: Medium-2: Low-1

Semester: V		
IMMUNOTECHNOLOGY (Theory)		
Course Code:16BT55		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours:33L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Understand the mechanism of immune response and reactions
2	Utilise various components and assets required for immune reaction
3	Comprehend structure of immunoglobulin and antibody
4	Apply various techniques for understanding intricacies of immunology
5	Figure out various tools and mechanism for graft rejection reactions

Unit-I	
Introduction to the immune system: Innate and acquired immunity, passive and adaptive immunization, cells and organs of the immune system; primary and secondary immune responses, humoral and cellular immunity, antigens: chemical and molecular nature, Hapten, adjuvant, Chemical Nature, Types of Antigenic determinants. Regulation of Immune response	**06 Hrs**
Unit – II	
Immunoglobulins and MHC: Immunoglobulins- General Structure, Classes of Immunoglobulin and Isotypes, Functions, Lymphocytes: T-Cells- Classes, Structure and organization of TCRs, B-Cells- Cell surface Receptors. Activation and function of T and B cells, Organization and polymorphism of MHC complex, Role of antigen presenting cells (APC); Antigen processing and presentation in the human response.	**07 Hrs**
Unit –III	
Immune effector mechanism :Cytokines; general properties and functional categories of cytokines, therapeutic and diagnostic exploitation of cytokines and cytokine receptors, Complement, Hypersenstivity; Cell-mediated effector responses-cytotoxicity, inflammation, Immunotolerance. Tumor immunology; Tumor antigen, categories of tumor antigen, tumor immunoprophylaxis.	**05 Hrs**
Unit –IV	
Antibody engineering and applications: Monoclonal antibodies, Generation of Recombinant antibodies from hybridoma, Antibody labeling for imaging and immunotherapy; Catalytic antibodies; Targeting antibodies using aptamers. Overview of Auto immunity; criteria and causes of autoimmune diseases-Autoimmune hemolytic anemia, myasthenia gravis, systemic lupus erythematosus, multiple sclerosis, rheumatoid arthritis, transplantation and graft rejection; mechanism; allograft rejection, bone marrow and haematopoietic stem cell transplantation.	**08 Hrs**
Unit –V	
Immunotechnology techniques: Antigen Antibody interactions; Precipitin & Agglutination reaction. Immunofluorescence, flow cytometry, Immuno double diffusion test Immunoelectrophoresis, Rocket Immuno electrophoresis, Radio immuno assay, ELISA technique for detection of diseases & Elispot assay. fluorescence activated cell sorting analysis and Chemiluminiscence.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Apprehend the concepts of immunity and immune reactions.
CO2:	Analyse the various types of immune responses
CO3:	Apply the knowledge of immunology to identify various immunological reactions and interactions
CO4:	Evaluate the significance and applications of various immunological techniques.

Reference Books	
1	Ashim K. Chakravarthy. Immunology and Immunotechnology Oxford University Press. 2006. ISBN-13: 978-0195676884
2	T. Kindt, R. Goldsby, B. A. Osborne, Kuby Immunology, W. H. Freeman, 6th edition, 2006. ISBN 13: 9781429202114
3	Benjamini E. and Leskowitz S. Immunology: A short course, Wiley Liss, NY. 2003. ISBN : 978-1-118-39690-2
4	Abbas A., Litchman A. H., and Pober J., "Cellular and Molecular Immunology" W B Saunders & Co.(2000), ISBN: 9780323222754

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	3	2	1	-	2	2	1	-	2
CO2	2	3	3	3	3	2	3	2	3	1	-	3
CO3	1	3	3	2	2	3	3	3	2	2	1	2
CO4	2	2	3	1	1	3	3	3	2	3	2	3

High-3: Medium-2: Low-1

Professional A

Semester: V		
PHARMACEUTICALS **(Group A: Professional Core Elective)**		
Course Code: 16BT5A1		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:1		**SEE Marks: 100**
Hours: 35L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Evaluate the nature of drugs, their formations and accruing benefits to mankind.
2	Illustrate the steps involved in the manufacturing of drugs and pharmaceutics preparations.
3	Demonstrate the types of drugs and their sites of action.
4	Acquaint the awareness about natural and semisynthetic products.

Unit-I	
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.	**07 Hrs**
Unit – II	
Manufacturing principles and formulations: Compressed tablets, wet and dry granulation, direct compression, tablet formulation and coating pills. Capsules formulation and manufacture. Drug delivery types, sustained action dosage formulations, parenteral preparations, oral liquids and topical ointments and balms. Application of recombinant proteins in pharmaceutical industry. Scale-up aspects. Concept of GMP and GLP- Clean room.	**07 Hrs**
Unit -III	
Chemical conversion processes and Drug metabolism: Alkylation, condensation, cyclization, dehydration, etc. Drug metabolism, half-life of drugs, physico-chemical principles in drug metabolism, use of radio-active compounds, pharmaco-kinetics and pharmacodynamics. Bioavailability and Bioequivalence.	**07 Hrs**
Unit –IV	
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	**07 Hrs**
Unit –V	
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. Immunomodulatory agents. Related case studies**.**	**07 Hrs**

Self-Study Topics

1. Approaches in drug discovery topics
2. Total quality control in pharmaceutical development process

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, HeribertWarzecha, John Wiley & Sons, 2012, ISBN: 352765125X, 9783527651252
2	Goodman and Gilman's Manual of Pharmacology and Therapeutics by Laurence L. Brunton, RandaHilal-Dandan. McGraw Hill Professional, 2013. ISBN: 007176917X, 9780071769174
3	J.P. Griffin and J. O'Grady; The text book of Pharmaceutical medicine; New Age International; 5th Ed; 2012; ISBN: 140518035
4	Laurence Brunton, Bruce Chabner, Bjorn Knollman; Goodman and Gilman's The Pharmacological Basis of Therapeutics, Twelfth Edition. McGraw Hill Professional, 2011. ISBN: 0071769390, 9780071769396

Continuous Internal Evaluation (CIE); Theory (50 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 05 marks adding up to 15 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 25 marks each and the sum of the marks scored from three tests is reduced to 30. The marks component for Assignment is 05. The total marks of CIE are 50.

Semester End Evaluation (SEE); Theory (50 Marks)

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 10 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 8 marks adding up to 40 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	1	-	1	2	3	1	3	-	-	2	1
CO2	2	2	3	3	2	3	-	3	1	-	1	2
CO3	1	3	1	3	-	3	1	3	2	-	1	-
CO4	2	-	2	3	-	3	-	2	1	-	-	-

High-3: Medium-2: Low-1

Semester: V		
AGRICULTURAL BIOTECHNOLOGY **(Group A: Professional Core Elective)**		
Course Code: 16BT5A2		**CIE Marks: 100**
Credits: L:P:T:S: 3:0:0:1		**SEE Marks: 100**
Hours: 34L		**SEE Duration: 3Hrs**

Course Learning Objectives:

1	Obtain a strong foundation in principles and fundamentals of plant cultures and its application.
2	Understand the various breeding techniques for crop improvement.
3	Emphasize on potential applications of genetically engineered crops
4	Get an overview of the various applications of agri-biotechnology

Unit-I	
Introduction: History and Scope, Tissue culture as a tool in crop improvement: Introduction to tissue culture, sterilization of field grown tissues, callus induction, initiation of suspension cultures, role of hormones in plant morphogenesis, regeneration of shoots and roots from callus cultures, micro propagation, secondary plant products and their methods of production, Synthetic seeds. Germplasm preservation.	**07 Hrs**
Unit – II	
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. Soma clonal variation.	**07 Hrs**
Unit -III	
Genetic Engineering: Principles of recombinant DNA technology, Methods of gene transfer: Transformation, transduction, Particle gun, Electroporation, liposome mediated, microinjection, Agro-bacterium mediated gene transfer, Preparation and application of molecular probes .Techniques for the insertion of foreign genes into plant cells. Ti plasmid and vectors, production of transgenic plants: Bt, herbicide and virus resistant plants. Radioactive labeling, Non-radioactive labeling, use of molecular probes, DNA fingerprinting,.	**07 Hrs**
Unit –IV	
Molecular Markers in Plant Breeding: Distinction between various morphological, biochemical and molecular markers with their strength and weaknesses. Types of molecular markers. PCR technology and its implications on molecular biology. Isozymes; RFLP; RAPD; ISSR;STMS; AFLP; SNP; SCAR; CAPS; RAMP; and SSCP markers (techniques, methodology and its application in plant and animal breeding). Functional expression markers. Application of molecular markers in plant breeding especially in varietal identification; markers assisted selection; QTL, mapping and map based cloning, mapping strategies.	**07 Hrs**
Unit –V	
Protected cultivation: Green house technology, Types of Green house, Various component of green house, Design, criteria and calculation. Green house irrigation system, Pytotrons: Hydroponics and aeroponics. Sustainable Agricultural systems: Organic Farming, Concept of Integrated nutrient management and Integrated pest management, molecular farming in animals and plants.	**06 Hrs**

Self Study:

1. Role of markers in Plant Breeding
2. Micropropagation of important commercial plant

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 analyze the improvement of agricultural practices and livestock
CO3:	Evaluate and analyze various parameters of transgenics for crop and livestock improvement
CO4:	Create and work on green house and other sustainable techniques

Reference Books	
1	Biotechnological Renovations in Crop Improvement by Biotol Series, Elsevier
2	S S Purohit, Agricultural Biotechnology, Agribios India, 2nd ed. 2003, digitalized 2011, ISBN: 81-7754-156-0
3	Gene cloning and DNA analysis : an introduction by Brown, T. A. 2001, 4th edition,
4	BlackwellSci. Ltd., BlackwellPub. Co., USA

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	1	-	1	2	-	-		-	-	-	1
CO2	2	2	3	3	2	-	-	2	-	-	1	2
CO3	1	3	1	3	2	1	-	-	-	-	1	-
CO4	2	-	2	3	1	-	-	-	-	-	-	-

High-3: Medium-2: Low-1

Semester: V		
PROCESS ENGINEERING **(Group A: Professional Core Elective)**		
Course Code:16BT5A3		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:1		**SEE Marks: 100**
Hours: 35L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	To impart the basic concepts of bioprocess technology.
2	To understand and explain the importance of Unit processes and unit operations in process industries.
3	To compare unit processes and individual operations used to produce value added products.
4	To develop flow sheets for various process operations.

Unit-I	
Introduction and overview of Process Technology. Study of chemical industries with reference to process technology, availability of raw materials, preparation of process flow sheet, production trends and future prospects, pollution and major engineering problems. Pulp and paper industry: Different pulping process; Recovery of chemicals from cooking liquors; Paper making; Role of additives. Oil, fats and waxes industry: Physical and chemical properties of oils and fats; Interesterification, transesterification and randomisation; Winning of oils and fats from vegetables and animal source; Refining; Vanaspati, margarine etc.; Waxes; Soaps	**07 Hrs**
Unit – II	
Food and food by-product industry: Sugar, glucose, fructose, starch; Food processing and reservation; Food by- products. Wood and wood chemicals industry: Composite wood, plywood etc.; Manufacture of oleoresin, turpentine, menthol, rosin, and tall oil; Ethanol production; Essential oils, perfumes, flavors and cosmetics.	**07 Hrs**
Unit -III	
Leather industry: Skin and hides; Tanning processes; Leather making; Embossing; Leather chemicals. **Petrochemical and synthetic chemical industries:** Petrochemicals derived from C1 Compounds (Methane and synthesis gas), C2 Compounds (Ethylene and acetylene), C3 compounds (Propylene) to C4 compounds (Butanes and Butenes).	**07 Hrs**
Unit –IV	
Fermentation and life processing industries: Production and isolation of Pencillin, Erythromycin, Streptomycin and Insulin. Production of Beer, wine and distilled liquors from fermentation process. Production of citric acid from dextrose glucose sugar	**07 Hrs**
Unit –V	
Pharmaceutical industries: Classification of drugs; Drug production based on some selected unit Processes. Agrochemical industries: Manufacturing process of some important pesticides, insecticides, fungicides, fumigants, plant growth regulators, yield stimulators and herbicides	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand and explain the fundamental concepts of bioprocess technology.
CO2:	Analyze and apply various unit processes and unit operations in various process industries.
CO3:	Develop the flow diagram and explain manufacturing process of different value added products.
CO4:	Identify and solve engineering problems during production.

Reference Books	
1	G.T. Austin, "Shreve's Chemical Process Industries", McGraw-Hill Book Co. New York, 5th edition 1984. ISBN: 0070661677, 9780070661677.
2	C.E Dryden,., "Outlines of Chemical Technology", Affiliated East-West Press, 2nd edition, 1993. ISBN: 10:8185938792, 13:978-8185938790.
3	"Chemtech" Volume I-IV, Chemical Engineering Education Development Centre, I.I.T., Madras.
4	S.D.Shukla, G.N.Pandey, A text book of Chemical technology, Sangam Books, 3rd edition, 2000. ISBN: 13:9780706904635.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	2	2	1	1	-	-	2
CO2	2	1	-	-	-	1	-	-	1	-	-	1
CO3	1	3	2	3	-	2	2	-	1	-	-	2
CO4	3	3	1	-	-	2	-	-	-	-	-	1

High-3: Medium-2: Low-1

Semester: V		
DATA STRUCTURES IN C AND C++ **(Group A: Professional Core Elective)**		
Course Code:16BT5A4		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:1		**SEE Marks: 100**
Hours :35L		**SEE Duration: 3Hrs**

Course Learning Objectives:

1	Explore conceptually programming applications in the domains of Life sciences and in general study the role of computer science in life sciences
2	Acquire knowledge of the Object Oriented Programming and Advanced programming skills in Data Structures in C and C++
3	Study data structures Stack, Queue, Linked Stack and queues, Trees and Tables
4	Understand the importance of various data structures to solve the problems related to High throughput Data analysis
5	Explore practically the applications of various data structures along with object oriented programming.

Unit-I	
Stacks: Introduction to data structures and Standard Template Library. Pointers, Generic types and templates, and structures. Stack specifications, Lists and Arrays. Implementation of Stacks, Application of stack - Reversing a list. Queues: Definitions, Queue Operations, Extended Queue Operations, Implementations of Queues - Circular Implementation of Queues. **Linked Stacks and Queues:** Linked stacks, Linked stacks with safeguards - Destructor, Overloading Assignment Operator and Copy Constructor. Modified linked-stack specification. Linked queues - Basic declarations, Extended linked queues.	**07 Hrs**
Unit – II	
Recursion: Introduction to Recursion, Stack Frames for Subprograms, Tree of Subprogram Calls, Factorials: A Recursive Definition, Divide and Conquer (Towers of Hanoi). Tail Recursion and Refinement. **Lists and Strings:** List definition, Method specifications, Implementation of lists, Class templates, Contiguous implementation, Simply linked and Doubly Linked implementation of Lists. Strings - Strings in C++, Implementation of strings, String operations. Linked lists in Arrays.	**07 Hrs**
Unit -III	
Searching: Searching: Introduction Basic search types - Sequential search, Binary search, Ordered lists. Algorithm Development and Asymptotics – Introduction, Orders of Magnitude, Big-O and Related Notations. **Sorting:** Introduction, Sort types – Bubble sort, Insertion sort, Merge sort, Selection sort, Shell sort, Divide-and-Conquer sorting, Merge sort for linked lists, Ordered insertion. Linked version. Analysis - Algorithm, Contiguous implementation and Comparisons. Analysis of Merge sort. Quick sort for Contiguous lists, Partitioning the list, Analysis of Quicksort, Comparison with Merge sort. Heaps and Heapsort,	**07 Hrs**
Unit –IV	
Tables and Information Retrieval: Introduction. Tables of various shapes, Triangular tables, Rectangular tables Jagged tables, Inverted tables. Hashing and Sparse tables. Collision resolution with Open Addressing, Collision Resolution by Chaining. Trees: Basic terminology. Binary trees - Binary tree representation, algebraic Expressions, Complete binary tree, Extended binary tree, Array and Linked representation of Binary trees. Traversing binary trees, threaded binary trees. Traversing Threaded binary trees, Huffman algorithm.	**07 Hrs**
Unit –V	
Graphs: Terminology & Representations, Graphs &Multi-graphs, Directed Graphs, Sequential representations of graphs - Adjacency matrices, Traversal, Connected component and Spanning Trees, Minimum Cost Spanning Trees and algorithms.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Define and explain concepts of Object Oriented Programming along with the possible data structures
CO2:	Apply Object Oriented programming and data structures to solve the problems in the area of Big Data Analytics
CO3:	Analyze and evaluate both set of sorting and searching algorithms with case studies
CO4:	Design and implement algorithms to perform high throughput data analysis in the field Sequence and structure analysis

Reference Books	
1	Adam Drozdek. Data Structures and Algorithms in C++. Cengage Learning, 4th ed., 2012. ISBN: 9781285415017.
2	Rajesh K. Shukla. Data Structures Using C & C++. Wiley India Pvt. Limited, 2009. ISBN: 9788126519972.
3	Brijendra Kumar Joshi. Data Structures and Algorithms in C++. Tata McGraw-Hill Education, 2010. ISBN: 9780070669109
4	Stefan Brandle, James Robergé, Jonathan Geisler, David Whittington. C++ Data Structures: A Laboratory Course. Jones & Bartlett Publishers, 2010. ISBN: 9781449660987.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	1	3	2	-	-	2			-
CO2	2	3	3	1	3	1	-	-		2	1	-
CO3	1	1	3	2	3	1	-	-	1	1	1	-
CO4	3	1	1	1	2	3	-	-				-

High-3: Medium-2: Low-1

Semester: V		
BIOINFORMATICS **(Group B: Global Elective)**		
Course Code: 16G5B01		**CIE Marks: 100**
Credits :L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours:04		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Understand the underlying technologies of Bioinformatics and Programming
2	Explore the various algorithms behind the computational genomics and proteomic structural bioinformatics, modeling and simulation of molecular systems.
3	Apply the tools and techniques that are exclusively designed as data analytics to investigate the significant meaning hidden behind the high throughput biological data.
4	Analyze and evaluate the outcome of tools and techniques employed in the processes of biological data preprocessing and data mining.

Unit-I	
Biomolecules: Introduction to Biomolecules. Structure, Types and Functions of Carbohydrates, Lipids, Nucleic Acids and Proteins. Genetic code, Codon degeneracy, Genes and Genomes. **Bioinformatics & Biological Databases:** Introduction to Bioinformatics, Goals, Scope, Applications in biological science and medicine. Biological databases – Sequence, structure, Special Databases and applications - Genome, Microarray, Metabolic pathway, motif, and domain databases. Mapping databases – genome wide maps. Chromosome specific human maps.	**09 Hrs**
Unit – II	
Sequence Alignment: Introduction, Types of sequence alignments - Pairwise and Multiple sequence alignment, Alignment algorithms (Needleman & Wunch, Smith & Waterman and Progressive global alignment). Database Similarity Searching-Scoring matrices – BLOSSUM and PAM, Basic Local Alignment Search Tool (BLAST), and FASTA. Next Generation Sequencing – Alignment and Assembly. **Molecular Phylogenetics:** Introduction, Terminology, Forms of Tree Representation. Phylogenetic Tree Construction Methods - Distance-Based & Character-Based Methods and Phylogenetic Tree evaluation.	**09 Hrs**
Unit -III	
Predictive methods: Predicting secondary structure of RNA, Protein and Genes – algorithms to predict secondary structure of RNA, Protein and Gene. Prediction of Tertiary structure of Protein, Protein identity and Physical properties of protein. **Molecular Modeling and Drug Designing:** Introduction to Molecular Modeling. Methods of Molecular Modeling and Force Fields used in Molecular Modeling. Drug designing process - deriving Pharmacophore, Receptor Mapping, Estimating Receptor-Ligand interactions and Molecular Docking.	**09Hrs**
Unit –IV	
Perl: Introduction to Perl, writing and executing a Perl program. Operators, Variables and Special variables. Data Types – Scalar, Array and Associative array. Regular Expressions (REGEX), Components of REGEX - Operators, Metacharacters and Modifiers. Subroutines – types of functions, defining and calling functions in Perl, calling function - call by value and call by reference. Object Oriented Programming in Perl–Class and object, Polymorphism, inheritance and encapsulation. Perl Package – writing and calling package. Perl Module – writing and calling module.	**09Hrs**
Unit –V	
BioPerl: Introduction to BioPerl, BioPerl Modules, Applications of BioPerl – Sequence retrieval from Database and submission of sequence to online Database,	**09 Hrs**

Indexing and accessing local databases, Transforming formats of database record, Sequence alignments BioPerl and Sequence Analysis - Pair wise and Multiple sequence alignment, Restriction mapping. Identifying restriction enzyme sites, acid cleavage sites, searching for genes and other structures on genomic DNA, Parsing BLAST and FASTA results. BioPerl and phylogenetic analysis, BioPerl and Phylogenetic tree manipulation, creating graphics for Sequence display and Annotation.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the Architecture and Schema of online databases including structure of records in these databases.
CO2:	Explore the Mind crunching Algorithms, which are used to make predictions in Biology, Chemical Engineering, and Medicine.
CO3:	Apply the principles of Bioinformatics and Programming to the problems related to process simulation and process engineering in Biological system.
CO4:	Use Bioinformatics tools and Next Generation Technologies to model and simulate biological phenomenon.

Reference Books	
1	T. Christiansen, B. D. Foy, L. Wall, J. Orwant, Programming Perl: Unmatched power for text processing and scripting, O'Reilly Media, Inc., 4th Edition, 2012, ISBN-13: 978-0596004927
2	B. Haubold, T. Weihe, Introduction to Computational Biology: An Evolutionary Approach, new age publishers, Paperback Edition, 2009, ISBN-13: 978-8184890624
3	C. Bessant, I. Shadforth, D. Oakley, Building Bioinformatics Solutions: with Perl, R and MySQL, Oxford University Press, 1st edition, 2009, ISBN
4	D. C. Young. Computational Drug Design: A Guide for Computational and Medicinal Chemists,Wiley-Interscience, 1st edition, 2009, ISBN-13: 978-0470126851.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	2	3	2	3	3	-	-	1	2	-
CO2	3	3	3	2	3	3	2	-	2	-	-	-
CO3	3	2	2	2	2	1	1	-	-	-	1	-
CO4	1	2	3	3	3	2	1	-	-	2	-	-

High-3: Medium-2: Low-1

Semester: V		
FUEL CELL TECHNOLOGY (Group B: Global Elective)		
Course Code: 16G5B02		**CIE Marks: 100**
Credits: L:T:P:S:: 4:0:0:0		**SEE Marks: 100**
Hours: 45L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to

1	Recall the concept of fuel cells
2	Distinguish various types of fuel cells and their functionalities
3	Know the applications of fuel cells in various domains
4	Understand the characterization of fuel cells

UNIT-I	
Introduction: Fuel cell definition, historical developments, working principle of fuel cell, components of fuel cell, EMF of the cell, Fuel Cell Reactions, fuels for cells and their properties.	**09Hrs**
UNIT-II	
Fuel Cell Types: Classification of fuel cells, alkaline fuel cell, polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, advantages and disadvantages of each.	**09Hrs**
UNIT-III	
Fuel Cell Reaction Kinetics: Activation kinetics, open circuit voltage, intrinsic maximum efficiency, voltage efficiency, Faradaic efficiency, overall efficiency, over-voltages and Tafel equation.	**09Hrs**
UNIT-IV	
Fuel Cell Characterization: Current – voltage curve, in-situ characterization, current – voltage measurement, current interrupt measurement, cyclic voltammetry, electrochemical impedance spectroscopy and ex-situ characterization techniques.	**09Hrs**
UNIT-V	
Applications of Fuel Cells: Applications of fuel cells in various sectors, hydrogen production, storage, handling and safety issues.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
1	Understand the fundamentals and characteristics of fuel cells
2	Apply chemical engineering principles to distinguish fuel cells from conventional energy systems
3	Analyze the performance of fuel cells using different characterization techniques
4	Evaluate the possibility of integrating fuel cell systems with conventional energy systems

Reference Books	
1.	Fuel Cells – Principles and Applications, Viswanathan and M Aulice Scibioh, 1st Edition, 2009, Universities Press, ISBN – 13: 978 1420 060287
2.	Fuel Cell Systems Explained, James Larminie and Andrew Dicks, 2nd Edition, 2003, John Wiley & Sons, ISBN – 978 0470 848579
3.	Fuel Cell Fundamentals, O 'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, 1st Edition, 2006, Wiley, New York, ISBN – 978 0470 258439
4.	Recent Trends in Fuel Cell Science and Technology, Basu. S, 1st Edition, 2007, Springer, ISBN – 978 0387 688152

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO - PO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**2**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**-**
CO 2	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO 3	**-**	**3**	**-**	**-**	**-**	**-**	**3**	**-**	**2**	**-**	**-**	**-**
CO 4	**-**	**2**	**2**	**-**	**-**	**-**	**2**	**-**	**3**	**-**	**-**	**2**

High-3: Medium-2: Low-1

Semester: V		
GEOINFORMATICS (Group B: Global Elective)		
Course Code:16G5B03		**CIE Marks: 100**
Hrs/Week: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Credits: 48L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	To understand concept of using photographic data to determine relative positions of points
2	To study the use of electromagnetic energy for acquiring qualitative and quantitative land information
3	To analyze the data gathered from various sensors and interpret for various applications
4	To understand the various applications of RS, GIS and GPS

UNIT-I	
Remote Sensing- Definition, types of remote sensing, components of remote sensing, Electromagnetic Spectrum, Black body, Atmospheric windows, energy interaction with earth surface features. spectral reflectance curve- physical basis for spectra reflectance curve, false color composite. Platforms and sensors. Sensor resolutions. Types of satellites- Indian and other remote sensing satellites (IRS, IKONS and Landsat). Concept of image interpretation and analysis - Principle of visual interpretation, recognition elements. Fundamentals of image rectification. Digital Image classification - supervised and unsupervised	**10 Hrs**
UNIT-II	
Photogrammetry: Introduction types of Photogrammetry, Advantages of Photogrammetry, Introduction to digital Photogrammetry. Locating points from two phases determination of focal length. **Aerial Photogrammetry:** Advantages over ground survey methods - geometry of vertical phographs, scales of vertical photograph. Ground coordination- relief displacement, scale ground coordinates – flight planning	**10 Hrs**
UNIT-III	
Geographic Information System- Introduction, Functions and advantages, sources of data for GIS. Database – Types, advantages and disadvantages. Data Management – Transformation, Projection and Coordinate systems. Data input methods, Data Analysis.-overlay operations, network analysis, spatial analysis. Outputs and map generation. . Introduction to GPS- components and working principles	**10 Hrs**
UNIT-IV	
Applications of GIS, Remote Sensing and GPS: Case studies on Water Resources engineering and management (prioritization of river basins, water perspective zones and its mapping), **Case studies on applications of GIS and RS** in highway alignment, Optimization of routes, accident analysis, Environmental related studies. **Case studies on applications of GIS and RS** in Disaster Management (Case studies on post disaster management - Earthquake and tsunami and pre disaster management - Landslides and floods) Urban Planning & Management - mapping of zones, layouts and infrastructures.	**09 Hrs**

UNIT-V	
Applications of GIS, Remote Sensing and GPS: Land use land cover (LULC) mapping. Case studies on infrastructure planning and management- Case studies on urban sprawl. Change detection studies – case studies on forests and urban area. Case studies on agriculture. **Applications of geo-informatics in natural resources management: Geo Technical case Studies**, site suitability analysis for various applications.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
1	Understand the principle of Remote Sensing (RS) and Geographical Information Systems (GIS) data acquisition and its applications.
2	Apply RS and GIS technologies in various fields of engineering and social needs.
3	Analyze and evaluate the information obtained by applying RS and GIS technologies.
4	Create a feasible solution in the different fields of application of RS and GIS.

Reference Books	
1.	Geographic Information System-An Introduction, Tor Bernharadsen, 3rd Edition, Wiley India Pvt. Ltd. New Delhi , 2009.
2.	Principles of Remote sensing and Image Interpretation, Lillesand and Kiefer, 5th Edition, John Wiley Publishers, New Delhi, 2007.
3.	Remote Sensing and GIS, Bhatta B, Oxford University Press, New Delhi, 2008
4.	Remote Sensing, Robert A. Schowengerdt, 3rd Edition, Elsevier India Pvt Ltd, New Delhi, 2009

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
CO1	1	-	-	-	-	1	-	-	-	-	-	-
CO2	2	1	-	-	1	1	-	-	-	-	-	-
CO3	2	2	1	-	2	1	1	-	-	-	-	1
CO4	2	2	1	-	3	2	2	-	-	-	1	1

Low-1 Medium-2 High-3

Semester: V		
GRAPH THEORY **(Group B : Global Elective)**		
Course Code:16G5B04		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 45L		**SEE Duration: 3 Hrs**

Course Learning Objectives: The students will be able to	
1	Understand the basics of graph theory and their various properties.
2	Model problems using graphs and to solve these problems algorithmically.
3	Apply graph theory concepts to solve real world applications like routing, TSP/traffic control, etc.
4	Optimize the solutions to real problems like transport problems etc.,

UNIT-I	
Introduction to graph theory: Introduction, Mathematical preliminaries, definitions and examples of graphs, degrees and regular graphs, sub graphs, directed graphs, in degrees and out degrees in digraphs. **Basic concepts in graph theory:** Paths and cycles, connectivity, homomorphism and isomorphism of graphs, connectivity in digraphs.	**09 Hrs**
UNIT-II	
Graph representations, Trees, Forests : Adjacency matrix of a graph, Incidence matrix of a graph, Adjacency lists, Trees and properties of trees, Characterization of trees, Centers of trees, Rooted trees, Binary threes, Spanning trees and forests, Spanning trees of complete graphs, An application to electrical networks, Minimum cost spanning trees.	**09 Hrs**
UNIT-III	
Fundamental properties of graphs and digraphs: Bipartite graphs, Eulerian graphs, Hamiltonian graphs, Hamiltonian cycles in weighted graphs, Eulerian digraphs. **Planar graphs, Connectivity and Flows:** Embedding in surfaces, Euler's formula, Characterization of planar graphs, Kuratowski's theorem, Dual of a planar graphs.	**09 Hrs**
UNIT-IV	
Matchings and Factors: Min-Max theorem, Independent sets and covers, Dominating sets, maximum bipartite matching. **Coloring of graphs:** The chromatic number of a graph, Results for general graphs, The chromatic polynomial of a graph, Basic properties of chromatic polynomial, chordal graphs, powers of graphs, Edge coloring of graphs	**09 Hrs**
UNIT-V	
Graph algorithms: Graph connectivity algorithms, Breadth first search and Depth first search, Shortest path algorithms, Dijikstra's shortest path algorithm, Minimum cost spanning tree algorithms, Algorithm of Kruskal's and Prim's.	**09Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1.	Understand and explore the basics of graph theory.
CO2.	Analyse the significance of graph theory in different engineering disciplines
CO3.	Demonstrate algorithms used in interdisciplinary engineering domains.
CO4.	Evaluate or synthesize any real world applications using graph theory.

Reference Books	
1.	Introduction to graph theory, Douglas B. West, 2nd Edition, 2001, PHI, ISBN- 9780130144003, ISBN-0130144002.
2.	Graph Theory, modeling, Applications and Algorithms, Geir Agnarsson, Raymond Greenlaw, Pearson Education, 1st Edition,2008, ISBN- 978-81-317-1728-8.
3.	Introduction to Algorithms, Cormen T.H., Leiserson C. E, Rivest R.L., Stein C. , 3rd Edition, 2010,PHI, ISBN:9780262033848

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**
CO2	**2**	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**2**	**2**	**-**	**1**
CO3	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**-**	**2**	**2**	**-**	**1**
CO4	**2**	**2**	**3**	**2**	**-**	**1**	**-**	**-**	**2**	**2**	**-**	**1**

Low-1 Medium-2 High-3

Semester: V		
ARTIFICIAL NEURAL NETWORKS &DEEP LEARNING (Group B: Global Elective)		
Course Code: 16G5B05		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 46L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	Define what is Neural Network and model a Neuron and Express both Artificial Intelligence and Neural Network
2	Analyze ANN learning, Error correction learning, Memory-based learning, Hebbian learning, Competitive learning and Boltzmann learning
3	Implement Simple perception, Perception learning algorithm, Modified Perception learning algorithm, and Adaptive linear combiner, Continuous perception, learning in continuous perception.
4	Analyze the limitation of Single layer Perceptron and Develop MLP with 2 hidden layers, Develop Delta learning rule of the output layer and Multilayer feed forward neural network with continuous perceptions,

UNIT-I	
Introduction to Neural Networks: Neural Network, Human Brain, Models of Neuron, Neural networks viewed as directed graphs, Biological Neural Network, Artificial neuron, Artificial Neural Network architecture, ANN learning, analysis and applications, Historical notes.	**08 Hrs**
UNIT-II	
Learning Processes: Introduction, Error correction learning, Memory-based learning, Hebbian learning, Competitive learning, Boltzmann learning, credit assignment problem, learning with and without teacher, learning tasks, Memory and Adaptation.	**10 Hrs**
UNIT-III	
Single layer Perception: Introduction, Pattern Recognition, Linear classifier, Simple perception, Perception learning algorithm, Modified Perception learning algorithm, Adaptive linear combiner, Continuous perception, Learning in continuous perception. Limitation of Perception.	**10 Hrs**
UNIT-IV	
Multi-Layer Perceptron Networks: Introduction, MLP with 2 hidden layers, Simple layer of a MLP, Delta learning rule of the output layer, Multilayer feed forward neural network with continuous perceptions, Generalized delta learning rule, Back propagation algorithm	**10 Hrs**
UNIT-V	
Introduction to Deep learning: Neuro architectures as necessary building blocks for the DL techniques, Deep Learning & Neocognitron, Deep Convolutional Neural Networks, Recurrent Neural Networks (RNN), feature extraction, Deep Belief Networks, Restricted Boltzman Machines, Autoencoders, Training of Deep neural Networks, Applications and examples (Google, image/speech recognition)	**08 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Model Neuron and Neural Network, and to analyze ANN learning, and its applications.
CO2:	Perform Pattern Recognition, Linear classification.
CO3:	Develop different single layer/multiple layer Perception learning algorithms
CO4:	Design of another class of layered networks using deep learning principles.

Reference Books	
1.	Neural Network- A Comprehensive Foundation , Simon Haykins, 2nd Edition, 1999, Pearson Prentice Hall, ISBN-13: 978-0-13-147139-9
2.	Introduction to Artificial Neural Systems, Zurada and Jacek M, 1992, West Publishing Company, ISBN: 9780534954604
3.	Learning & Soft Computing, Vojislav Kecman, 1st Edition, 2004, Pearson Education, ISBN:0-262-11255-8
4.	Neural Networks Design, M T Hagan, H B Demoth, M Beale, 2002, Thomson Learning, ISBN-10: 0-9717321-1-6/ ISBN-13: 978-0-9717321-1-7

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**
CO2	**3**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**
CO3	**3**	**3**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**
CO4	**3**	**3**	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**

Low-1 Medium-2 High-3

Semester: V		
HYBRID ELECTRIC VEHICLES (Group B: Global Elective)		
Course Code : 16G5B06		**CIE Marks : 100**
Credits : L:T:P:S 4:0:0:0		**SEE Marks : 100**
Hours : 45L		**SEE Duration : 3Hrs**

Course Learning Objectives: The students will be able to,	
1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2	Explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
3	Analyze various electric drives suitable for hybrid electric vehicles and Different energy storage technologies used for hybrid electric vehicles and their control.
4	Demonstrate different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management.

Unit-I	
Introduction: Sustainable Transportation, A Brief History of HEVs, Why EVs Emerged and Failed, Architectures of HEVs, Interdisciplinary Nature of HEVs, State of the Art of HEVs, Challenges and Key Technology of HEVs. **Hybridization of the Automobile:** Vehicle Basics, Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV), Basics of Fuel Cell Vehicles (FCVs).	07 Hrs
Unit-II	
HEV Fundamentals: Introduction, Vehicle Model, Vehicle Performance, EV Powertrain Component Sizing, Series Hybrid Vehicle, Parallel Hybrid Vehicle, Wheel Slip Dynamics. **Plug-in Hybrid Electric Vehicles:** Introduction to PHEVs, PHEV Architectures, Equivalent Electric Range of Blended PHEVs, Fuel Economy of PHEVs, Power Management of PHEVs, Component Sizing of EREVs, Component Sizing of Blended PHEVs, Vehicle-to-Grid Technology.	10 Hrs
Unit-III	
Power Electronics in HEVs: Power electronics including switching, AC-DC, DC-AC conversion, electronic devices and circuits used for control and distribution of electric power, Thermal Management of HEV Power Electronics. **Batteries, Ultracapacitors, Fuel Cells, and Controls:** Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System.	10 Hrs
Unit-IV	
Electric Machines and Drives in HEVs: Introduction, BLDC motors, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors, Thermal Analysis and Modelling of Traction Motors. **(only functional treatment to be given**)	10Hrs
Unit-V	
Integration of Subsystems: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems. **Energy Management Strategies:** Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.	08Hrs

Course Outcomes: After completing the course, the students will be able to	
1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2	Evaluate the performance of electrical machines and power electronics converters in HEVs.
3	Analyse the different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology
4	Design and evaluate the sizing of subsystem components and Energy Management strategies in HEVs.
Reference Books:	
1.	Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives, Mi Chris, Masrur A.and Gao D.W. Wiley Publisher, 1st Edition, 2011,*ISBN*:0-824-77653-5
2.	Ali, Modern Electric, Hybrid electric and Fuel Cell Vehicles, Ehsani Mehrdad, Gao Yimin, E. Gay Sebastien, Emadi CRC Press, 1st Edition, 2005, ISBN: *0-8493-3154-4.*
3.	Modern Electric Vehicle Technology, Chan, C.C.,Chau, K.T. Oxford University Press, 2001, ISBN 0 19 850416 0.
4.	Hybrid Electric Vehicles: Energy Management Strategies, Simona Onori, Lorenzo Serrao, Giorgio Rizzoni, *ISBN*: 978-1-4471-6779-2.

Continuous Internal Evaluation (CIE); Theory (100 Marks):

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Semester End Evaluation (SEE); Theory (100 Marks):

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**2**	**3**	**2**	**2**	**1**	**1**	**3**	**1**	**-**	**1**	**-**	**2**
CO2	**3**	**3**	**2**	**2**	**3**	**-**	**3**	**-**	**2**	**1**	**2**	**1**
CO3	**2**	**3**	**2**	**2**	**2**	**2**	**3**	**1**	**1**	**1**	**-**	**1**
CO4	**3**	**3**	**3**	**3**	**3**	**1**	**3**	**3**	**3**	**3**	**1**	**3**

High-3 : Medium-2 : Low-1

V Semester		
OPTIMIZATION TECHNIQUES **(Theory)** **(Open Elective B)**		
Course Code : 16G5B07		**CIE Marks : 100**
Credits : L: T: P: S:4:0:0:0		**SEE Marks : 100**
Hours : 44L		**SEE Duration : 03 Hrs**

Course Learning Objectives: The students will be able to	
1.	To understand the concepts behind optimization techniques.
2.	To explain the modeling frameworks for solving problems using optimization techniques.
3.	To design and develop optimization models for real life situations.
4.	To analyze solutions obtained using optimization methods.
5.	To compare models developed using various techniques for optimization.

UNIT – I	
Introduction: OR Methodology, Definition of OR, Application of OR to Engineering and Managerial problems, Features of OR models, Limitations of OR.	**09 Hrs**
Linear Programming: Definition, Mathematical Formulation, Standard Form, Solution Space, Types of solution – Feasible, Basic Feasible, Degenerate, Solution through Graphical Method. Problems on Product Mix, Blending, Marketing, Finance, Agriculture and Personnel. **Simplex methods:** Variants of Simplex Algorithm – Use of Artificial Variables.	
UNIT – II	
Duality and Sensitivity Analysis: Graphical sensitivity analysis, Algebraic sensitivity analysis - changes in RHS, Changes in objectives, Primal-Dual relationships, Economic interpretation of duality, Post optimal analysis - changes affecting feasibility and optimality, Revised simplex method	**09 Hrs**
UNIT – III	
Transportation Problem: Formulation of Transportation Model, Basic Feasible Solution using North-West corner, Least Cost, Vogel's Approximation Method, Optimality Methods, Unbalanced Transportation Problem, Degeneracy in Transportation Problems, Variants in Transportation Problems **Assignment Problem:** Formulation of the Assignment problem, solution method of assignment problem-Hungarian Method, Variants in assignment problem, Travelling Salesman Problem (TSP).	**08 Hrs**
UNIT – IV	
Queuing Theory: Queuing system and their characteristics, The M/M/I Queuing system, Steady state performance analyzing of M/M/1 queuing models. Introduction to M/M/C and M/Ek/1 queuing models **Game Theory**: Introduction, Two person Zero Sum game, Pure strategies, Games without saddle point - Arithmetic method, Graphical Method, The rules of dominance	**09Hrs**
UNIT – V	**09 Hrs**
Markov chains: Definition, Absolute and n-step transition probabilities, Classification of the states, Steady state probabilities and mean return times of ergodic chains, First passage times, Absorbing states. Applications in weather prediction and inventory management. Over view of OR software's used in practice.	

Course Outcomes: After going through this course the student will be able to	
CO1	Understand the various optimization models and their areas of application.
CO2	Explain the process of formulating and solving problems using optimization methods.
CO3	Develop models for real life problems using optimization techniques.
CO4	Analyze solutions obtained through optimization techniques.
CO5	Create designs for engineering systems using optimization approaches.

Reference Books:	
1.	Operation Research An Introduction, Taha H A, 8th Edition, 2009, PHI, ISBN: 0130488089.
2.	Principles of Operations Research – Theory and Practice, Philips, Ravindran and Solberg, 2nd Edition, 2000, John Wiley & Sons (Asia) Pte Ltd, ISBN 13: 978-81-265-1256-0
3.	Introduction to Operation Research, Hiller, Liberman, Nag, Basu, 9th Edition, 2012,Tata McGraw Hill, ISBN 13: 978-0-07-133346-7
4.	Operations Research Theory and Application, J K Sharma, 4th Edition, 2009, Pearson Education Pvt Ltd, ISBN 13: 978-0-23-063885-3.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2											
CO2	2	2		1	1							
CO3							1	1				
CO4	2		3		1							
CO5			2			1						1

Low-1 Medium-2 High-3

V Semester		
SENSORS & APPLICATIONS (Group B: Global Elective)		
Course Code:16G5B08		**CIE Marks: 100**
Credits/Week: L:T:P:S:4:0:0:0		**SEE Marks: 100**
Hours:44L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to

1	Impart the principles and working modes of various types of Resistive, Inductive, Capacitive, Piezoelectric and Special transducers.
2	Give an idea about the applications of various transducers and selection criteria of a transducer for a particular application.
3	Give an insight into the static and dynamic characteristics of different orders of instruments.
4	Describe different data conversion techniques and their applications.

UNIT-I	
Introduction: Definition of a transducer, Block Diagram, Active and Passive Transducers, Advantages of Electrical transducers. **Resistive Transducers:** Potentiometers: Characteristics, Loading effect, and problems. **Strain gauge:** Theory, Types, applications and problems. **Thermistor, RTD:** Theory, Applications and Problems.	**09 Hrs**
UNIT-II	
Thermocouple: Measurement of thermocouple output, compensating circuits, lead compensation, advantages and disadvantages of thermocouple. **LVDT:** Characteristics, Practical applications and problems. **Capacitive Transducers:** Capacitive transducers using change in area of plates, distance between plates and change of dielectric constants, Applications of Capacitive Transducers and problems.	**10 Hrs**
UNIT-III	
Piezo-electric Transducers: Principles of operation, expression for output voltage, Piezo-electric materials, equivalent circuit, loading effect, and Problems. **Special Transducers:** Hall effect transducers, Thin film sensors, and smart transducers: Principles and applications, Introduction to MEMS Sensors and Nano Sensors, Schematic of the design of sensor, applications.	**10 Hrs**
UNIT-IV	
Chemical sensors: pH value sensor, dissolved oxygen sensor, oxidation-reduction potential sensor. **Light sensors**: Photo resistor, Photodiode, Phototransistor, Photo-FET, Charge coupled device. **Tactile sensors:** Construction and operation, types.	**08 Hrs**
UNIT-V	
Data Converters: Introduction to Data Acquisition System, types of DAC, Binary Weighted DAC, R-2R ladder DAC, DAC-0800, Types of ADC, Single Slope ADC and Dual-slope integrated type ADC, Flash ADC, 8-bit ADC-0808, Programmable Gain Amplifier.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember and understand the basic principles of transducers and smart sensors.
CO2:	Apply the knowledge of transducers and sensors to comprehend digital instrumentation systems.
CO3:	Analyze and evaluate the performance of different sensors for various applications.
CO4:	Design and create a system using appropriate sensors for a particular application

Reference Books	
1	Electrical and Electronic Measurements and Instrumentation, A.K. Sawhney, 18th Edition, 2008, Dhanpat Rai and Sons, ISBN: 81-7700-016-0.
2	Sensor systems: Fundamentals and applications, Clarence W.de Silva, 2016 Edition, CRC Press, ISBN: 9781498716246.
3	Transducers and Instrumentation, D.V.S. Murthy, 2nd Edition 2008, PHI Publication, ISBN: 978-81-203-3569-1.
4	Introduction to Measurement and Instrumentation, Arun K. Ghosh, 3rd Edition, 2009, PHI, ISBN: 978-81-203-3858-6.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marksis executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO MAPPING												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO2	**2**	**3**	**-**	**-**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**
CO3	**1**	**2**	**2**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**2**
CO4	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**3**	**-**	**1**

Low-1 Medium-2 High-3

Semester: V		
INTRODUCTION TO MANAGEMENT INFORMATION SYSTEMS (Group B: Global Elective)		
Course Code: 16G5B09		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours :45L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	To understand the basic principles and working of information technology.
2	Describe the role of information technology and information systems in business.
3	To contrast and compare how internet and other information technologies support business processes.
4	To give an overall perspective of the importance of application of internet technologies in business administration.

UNIT I	
Information Systems in Global Business Today: The role of information systems in business today, Perspectives on information systems, Contemporary approaches to information systems, Hands-on MIS projects. **Global E-Business and Collaboration** : Business process and information systems, Types of business information systems, Systems for collaboration and team work, The information systems function in business. A Case study on E business.	**09 Hrs**
UNIT II	
Information Systems, Organizations and Strategy: Organizations and information systems, How information systems impact organization and business firms, Using information systems to gain competitive advantage, management issues, **Ethical and Social issues in Information Systems**: Understanding ethical and Social issues related to Information Systems, Ethics in an information society, The moral dimensions of information society. A Case study on business planning.	**09 Hrs**
UNIT III	
IT Infrastructure and Emerging Technologies : IT infrastructure, Infrastructure components, Contemporary hardware platform trends, Contemporary software platform trends, Management issues**. Securing Information Systems**: System vulnerability and abuse, Business value of security and control, Establishing framework for security and control, Technology and tools for protecting information resources. A case study on cybercrime.	**09 Hrs**
UNIT IV	
Achieving Operational Excellence and Customer Intimacy: Enterprise systems, Supply Chain Management (SCM) systems, Customer relationship management (CRM) systems, Enterprise application. **E-commerce: Digital Markets Digital Goods**: E-commerce and the internet, E-commerce-business and technology, The mobile digital platform and mobile E-commerce, Building and E-commerce web site. A Case study on ERP.	**09 Hrs**
UNIT V	
Managing Knowledge: The knowledge management landscape, Enterprise-wide knowledge management system, Knowledge work systems, Intelligent techniques. **Enhancing Decision Making**: Decision making and information systems, Business intelligence in the enterprise. Business intelligence constituencies. **Building Information Systems**: Systems as planned organizational change, Overview of systems development.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand and apply the fundamental concepts of information systems.
CO2:	Develop the knowledge about management of information systems.
CO3:	Interpret and recommend the use information technology to solve business problems.
CO4:	Apply a framework and process for aligning organization's IT objectives with business strategy.
Reference Books	
1	Management Information System, Managing the Digital Firm, Kenneth C. Laudon and Jane P. Laudon, 14th Global Edition, 2016, Pearson Education, ISBN:9781292094007
2	Management Information Systems, James A. O' Brien, George M. Marakas, 10th Edition, 2011, Global McGraw Hill, ISBN: 978-0072823110
3	Information Systems The Foundation of E-Business, Steven Alter, 4th Edition, 2002, Pearson Education, ISBN:978-0130617736
4	W.S. Jawadekar, Management Information Systems, Tata McGraw Hill, 2006, ISBN: 9780070616349

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	-	1	-	-	-	1	-	-	1	-
CO2	1	2	-	1	-	-	-	1	-	-	1	-
CO3	-	-	3	2	2	-	-	1	-	1	1	-
CO4	-	-	2	1	-	-	-	1	-	1	1	-

Low-1 Medium-2 High-3

Semester: V		
INDUSTRIAL AUTOMATION (Theory)		
Course Code: 16GB510		**CIE Marks: 100**
Credits: L:T:P:S : 4:0:0:0		**SEE Marks: 100**
Hours: 44L		**SEE Duration: 3 Hrs**

Course Learning Objectives: The students should be able to:	
1	Identify types of actuators, sensors and switching devices for industrial automation
2	Explain operation and controls of Hydraulic and Pneumatic systems
3	Understand fundamentals of CNC, PLC and Industrial robots
4	Define switching elements and sensors which are interfaced in an automation system
5	Describe functions of Industrial switching elements and Inspection technologies for automation
6	Select sensors to automatically detect motion of actuators
7	Develop manual part programs for CNC and Ladder logic for PLC
8	Develop suitable industrial automation systems using all the above concepts

UNIT-I	
Automation in Production Systems: Manufacturing support systems, Automation principles and strategies, Levels of Automation, Production Concepts and Mathematical models, Numericals **Automated Production Lines:** Fundamentals, Applications, Analysis with no storage, Analysis with storage buffer, Numericals	**08 Hrs**
UNIT-II	
Switching theory and Industrial switching elements Binary elements, binary variables, Basic logic gates, Theorems of switching algebra, Algebraic simplification of binary function, Karnough maps, Logic circuit design, problems. Electromechanical relays, Moving part logic elements, Fluidic elements, Timers, Comparisons between switching elements, Numericals **Industrial Detection Sensors and Actuators:** Introduction, Limit switches, Reed switches, Photoelectric sensors- methods of detection, Hall effect sensors, Inductive proximity sensors, Capacitive proximity sensors, Pneumatic back pressure sensors, Absolute encoder, Incremental encoder, Pressure switches and temperature switches; their working principles and applications, Brushless DC motors, Stepper motors and Servo motors	**08 Hrs**
UNIT-III	
Hydraulic Control circuits Components, Symbolic representations, Control of Single and Double Acting Cylinder, Regenerative Circuit application, Pump unloading circuit, Double Pump Hydraulic System, speed control circuits, accumulator circuits **Pneumatic Control circuits** Components, Symbolic representations as per ISO 5599, Indirect control of double acting cylinders, memory control circuit, cascading design, automatic return motion, quick exhaust valve circuit, and cyclic operation of a cylinder, pressure sequence valve and time delay valve circuits.	**10 Hrs**
UNIT-IV	
Introduction to CNC Numerical control, components of CNC, classification, coordinate systems, motion control strategies, interpolation, programming concepts **Industrial Robotics** Components of Robots, base types, classification of robots, end of arm tooling, robot precision of movement, programming, justifying the use of a robot, simple numericals	**08 Hrs**
UNIT-V	
Programmable logic control systems Difference between relay and PLC circuits, PLC construction, principles of operation, latching, ladder diagrams, programming instructions, types of timers, forms of counters, writing simple	**10 Hrs**

ladder diagrams from narrative description and Boolean logic. **Programming exercises on PLC with Allen Bradley controller** Programming exercises on motor control in two directions, traffic control, annunciator flasher, cyclic movement of cylinder, can counting, conveyor belt control, alarm system, sequential process, and continuous filling operation on a conveyor.	

Course Outcomes: After completing the course, the students will be able to	
1	Illustrate applications of sensors actuators, switching elements and inspection technologies in industrial automation
2	Build circuit diagrams for fluid power automation, Ladder diagrams for PLC and identify its application areas
3	Evaluate CNC programs for 2D complex profiles performed on machining and turning centres interfaced with Robots
4	Develop suitable industrial automated system integrating all of the above advanced automation concepts

Reference Books	
1.	Industrial automation - Circuit design and components , David W. Pessen, 1st Edition, 2011, Wiley India, ISBN –13–978–8126529889
2.	Pneumatic Controls , Joji P, 1st Edition, Wiley India, ISBN – 978–81–265–1542–4
3.	Fluid Power with Applications , Anthony Esposito, 7th Edition , 2013, ISBN – 13; 978– 9332518544
4.	Automation, Production systems and Computer Integrated Manufacturing , Mikell P. Groover, 3rd Edition , 2014 , ISBN – 978–81–203–3418–2

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**				**2**	**1**	**2**	**1**			**1**	**2**
CO2	**1**		**2**	**3**	**2**	**2**	**2**			**2**		
CO3		**1**		**2**	**1**					**2**		
CO4			**3**	**2**	**2**	**1**		**2**	**2**	**3**	**2**	**2**

Low-1 Medium-2 High-3

Semester: V		
TELECOMMUNICATION SYSTEMS **(Group B: Global Elective)**		
Course Code: 16G5B11		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 46L		**SEE Duration: 03Hrs**

Course Learning Objectives: The students will be able to	
1	Represent schematic of communication system and identify its components.
2	Classify satellite orbits and sub-systems for communication.
3	Analyze different telecommunication services, systems and principles.
4	Explain the role of optical communication system and its components.
5	Describe the features of wireless technologies and standards.

UNIT-I	
Introduction to Electronic Communication: The Significance of Human Communication, Communication Systems, Types of Electronic Communication, Modulation and Multiplexing, Electromagnetic Spectrum, Bandwidth, A Survey of Communication Applications. **The Fundamentals of Electronics**: Gain, Attenuation, and Decibels.	**09 Hrs**
UNIT-II	
Modulation Schemes: Analog Modulation: AM, FM and PM- brief review. **Digital Modulation:** PCM, Line Codes, ASK, FSK, PSK, and QAM. **Wideband Modulation:** Spread spectrum, FHSS, DSSS. **Multiplexing and Multiple Access Techniques:** Frequency division multiplexing, Time division multiplexing **Multiple Access**: FDMA, TDMA, CDMA, Duplexing.	**10 Hrs**
UNIT-III	
Satellite Communication: Satellite Orbits, Satellite Communication Systems, Satellite Subsystems, Ground Stations, Satellite Applications, Global Positioning System.	**09 Hrs**
UNIT-IV	
Optical Communication: Optical Principles, Optical Communication Systems, Fiber-Optic Cables, Optical Transmitters and Receivers, Wavelength-Division Multiplexing, Passive Optical Networks.	**09 Hrs**
UNIT-V	
Cell Phone Technologies: Cellular concepts, Frequency allocation, Frequency reuse. Advanced Mobile Phone System (AMPS) **Digital Cell Phone Systems:** 2G, 2.5G, 3G and 4G cell phone systems, Advanced Cell Phones. **Wireless Technologies:** Wireless LAN, PANs and Bluetooth, ZigBee and Mesh Wireless Networks, WiMAX and Wireless Metropolitan-Area Networks.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the basics of communication systems.
CO2	Analyze the importance of modulation and multiple access schemes for communication systems.
CO3	Compare different telecommunication generations, wired and wireless communication.
CO4	Justify the use of different components and sub-system in advanced communication systems.

Reference Books	
1.	Principles of Electronic Communication Systems, Louis E. Frenzel, 3rd Edition, 2008, Tata McGraw Hill, ISBN: 978-0-07-310704-2.

2.	Electronic Communication Systems, Roy Blake, 2nd Edition, 2002, Thomson/Delamar, ISBN: 978-81-315-0307-2.
3.	Electronic Communication Systems, George Kennedy, 3rd Edition, 2008, Tata McGraw Hill ISBN: 0-02-800592-9.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1	---	1	1	---	---	---	1	---	---	---
CO2	2	1	---	1	1	---	---	---	1	---	---	---
CO3	2	1	---	1	1	---	---	---	2	---	---	---
CO4	1	1	---	1	1	1	---	---	1	---	---	---

Low-1 Medium-2 High-3

Semester: V		
COMPUTATIONAL ADVANCED NUMERICAL METHODS (Group B: Global Elective)		
Course Code:16G5B12		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 44L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Adequate exposure to learn alternative methods and analyze mathematical problems to determine the suitable numerical techniques.
2	Use the concepts of interpolation, eigen value problem techniques for mathematical problems arising in various fields.
3	Solve initial value and boundary value problems which have great significance in engineering practice using ordinary differential equations.
4	Demonstrate elementary programming language, implementation of algorithms and computer programs to solve mathematical problems.

Unit-I	
Algebraic and Transcendental equations: Roots of equations in engineering practice, Polynomials and roots of equations, Fixed point iterative method, Aitken's process, Muller's method, Chebychev method.	**08 Hrs**
Unit – II	
Interpolation: Introduction to finite differences, Finite differences of a polynomial, Divided differences and Newton's divided difference interpolation formula, Hermite interpolation, Spline interpolation–linear, quadratic and cubic spline interpolation.	**08 Hrs**
Unit –III	
Ordinary Differential Equations: Solution of second order initial value problems–Runge-Kutta method, Milne's method, Boundary value problems (BVP's)–Shooting method, Finite difference method for linear and nonlinear problems, Rayleigh-Ritz method.	**09Hrs**
Unit –IV	
Eigen value problems: Eigen values and Eigen vectors, Power method, Inverse Power method, Bounds on Eigen values, Greschgorin circle theorem, Jacobi method for symmetric matrices, Givens method.	**09Hrs**
Unit –V	
Computational Techniques: Algorithms and Matlab programs for Fixed point iterative method, Aitken's–process, Muller's method, Chebychev method, Newton's divided difference method, Hermite interpolation, Spline interpolation, Power method, Inverse Power method, Runge-Kutta method, Milne's method, Shooting method, Rayleigh-Ritz method, Jacobi method and Givens method.	**10 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Identify and interpret the fundamental concepts of polynomial equations, Interpolation, Eigen value problems, Differential equations and corresponding computational techniques.
CO2:	Apply the knowledge and skills of computational techniques to solve algebraic and

	transcendental equations, Ordinary differential equations and eigen value problems.
CO3:	Analyze the physical problem and use appropriate method to solve roots of equations, Interpolating the polynomial, Initial and boundary value problems, Eigen value problems numerically using computational techniques.
CO4:	Distinguish the overall mathematical knowledge gained to demonstrate and analyze the problems of finding the roots of equations, Interpolation, Differential equations, Eigen value problems arising in engineering practice.
Reference Books	
1	Numerical methods for scientific and engineering computation, M. K. Jain, S. R. K. Iyengar and R. K. Jain, New Age International Publishers, 6th Edition, 2012, ISBN-13: 978-81-224-2001-2.
2	Numerical Analysis, Richard L. Burden and J. Douglas Faires, Cengage Learning, 9th Edition, 2012, ISBN-13: 978-81-315-1654-6.
3	Introductory Methods of Numerical Analysis, S. S. Sastry, PHI Learning Private Ltd., 4th Edition, 2011, ISBN: 978-81-203-2761-0.
4	Numerical Methods for Engineers, Steven C Chapra, Raymond P Canale, Tata Mcgraw Hill, 5th Edition, 2011, ISBN-10: 0-07-063416-5.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO2	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO3	**2**	**3**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
CO4	**3**	**3**	**1**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**3**

High-3: Medium-2: Low-1

Semester: V		
BASICS OF AEROSPACE ENGINEERING (Group B: Global Elective)		
Course Code: 16GE5B13		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 44L		**SEE Duration: 3Hours**

Course Learning Objectives: To enable the students to:	
1	Understand the history and basic principles of aviation
2	Demonstrate and explain foundation of flight, aircraft structures, material, aircraft propulsion
3	Comprehend the importance of all the systems and subsystems incorporated on a air vehicle
4	Appraise the significance of all the subsystems in achieving a successful flight

Unit-I	
Introduction to Aircraft : History of aviation, International Standard atmosphere, Atmosphere and its properties, Temperature, pressure and altitude relationships, Classification of aircrafts, Anatomy of an aircraft & Helicopters, Basic components and their functions, Introduction to Unconventional and Autonomous Air vehicles.	**08 Hrs**
Unit – II	
Basics of Aerodynamics : Bernoulli's theorem, Aerodynamic forces and moments on an Airfoil, Lift and drag, Types of drag, Centre of pressure and its significance, Aerodynamic centre, Aerodynamic Coefficients, Wing Planform Geometry, Airfoil nomenclature, Basic characteristics of airfoils, NACA nomenclature, Simple problems on lift and drag.	**08 Hrs**
Unit -III	
Aircraft Propulsion : Introduction, Classification of powerplants, Piston Engine: Types of reciprocating engines, Principle of operation of turbojet, turboprop and turbofan engines, Introduction to ramjets and scramjets, Comparative merits and demerits of different types Engines.	**07 Hrs**

Unit -IV	
Introduction to Space Flight : History of space flight, Evolution of Indian Space Technology, The upper atmosphere, Introduction to basic orbital mechanics, some basic concepts, Kepler's Laws of planetary motion, Orbit equation, Space vehicle trajectories**.** **Rocket Propulsion :** Principles of operation of rocket engines, Classification of Rockets, Types of rockets.	**08 Hrs**
Unit -V	
Aerospace Structures and Materials : Introduction, General types of construction, Monocoque, Semi-Monocoque and Geodesic structures, Typical wing and fuselage structure; Metallic and non-metallic materials for aircraft application. Use of aluminum alloy, titanium, stainless steel and composite materials, Low temperature and high temperature materials.	**07 Hrs**

Course Outcomes: At the end of this course the student will be able to	
1	Appreciate and apply the basic principles of aviation
2	Apply the concepts of fundaments of flight, basics of aircraft structures, aircraft propulsion and aircraft materials during the development of an aircraft
3	Comprehend the complexities involved during development of flight vehicles.
4	Evaluate and criticize the design strategy involved in the development of airplanes

Reference Books	
1	John D. Anderson, Introduction to Flight, 7th Edition, 2011, McGraw-Hill Education, ISBN 9780071086059.
2	Sutton G.P., Rocket Propulsion Elements, 8th Edition, 2011, John Wiley, New York, ISBN:1118174208, 9781118174203.
3	Yahya, S.M, Fundamentals of Compressible Flow, 5th Edition, 2016, New Age International, ISBN: 8122440223
4	T.H.G Megson, Aircraft structural Analysis, 2010, Butterworth-Heinemann Publications, ISBN: 978-1-85617-932-4

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

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CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**2**	**2**	**3**	**2**	**1**	**1**	**1**				**1**
CO3	**1**		**3**	**3**								**1**
CO4	**2**	**2**	**3**	**3**		**2**	**2**	**2**				**1**

High-3: Medium-2: Low-1

VI SEMESTER			
INTELLECTUAL PROPERTY RIGHTS AND ENTREPRENEURSHIP (Theory) (Common to BT, CHE, CV, E&I, IEM, ME)			
Course Code: 16HSI61			**CIE Marks:** 100
Credits: L:T:P:S: 3:0:0:0			**SEE Marks:** 100
Hours: 36L			**SEE Duration:** 03Hrs
Course Learning Objectives: The students will be able to			
1	To build awareness on the various forms of IPR and to build the perspectives on the concepts and to develop the linkages in technology innovation and IPR.		
2	To equip students on the need to protect their own intellectual works and develop ethical standards governing ethical works.		
3	To motivate towards entrepreneurial careers and build strong foundations skills to enable starting, building and growing a viable as well as sustainable venture.		
4	Develop an entrepreneurial outlook and mind set along with critical skills and knowledge to manage risks associated with entrepreneurs.		
UNIT-I			
Introduction: Types of Intellectual Property, WIPO, WTO, TRIPS. **Patents:** Introduction, Scope and salient features of patent; patentable and non-patentable inventions, Patent Procedure - Overview, Transfer of Patent Rights; Biotechnology patents, protection of traditional knowledge, Infringement of patents and remedy, Case studies **Trade Secrets:** Definition, Significance, Tools to protect Trade secrets in India.			**07 Hrs**
UNIT-II			
Trade Marks: Concept, function and different kinds and forms of Trade marks, Registrable and non- registrable marks. Registration of trade mark; Deceptive similarity; Assignment and transmission; ECO Label, Passing off; Offences and penalties. Infringement of trade mark with Case studies			**04 Hrs**
UNIT-III			
Industrial Design: Introduction, Protection of Industrial Designs, Protection and Requirements for 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, Case Studies. **Intellectual property and cyberspace:** Emergence of cyber-crime; Grant in software patent and Copyright in software; Software piracy; Data protection in cyberspace			**09 Hrs**
UNIT-IV			
Introduction to Entrepreneurship: Learn how entrepreneurship has changed the world. Identify six entrepreneurial myths and uncover the true facts. Explore E-cells on Campus **Listen to Some Success Stories:** Global legends Understand how ordinary people become successful global entrepreneurs, their journeys, challenges and success stories. Understand how ordinary people from their own countries have become successful entrepreneurs. **Characteristics of a Successful Entrepreneur** Understand the entrepreneurial journey and learn the concept of different entrepreneurial styles. Identify your own entrepreneurship style based on your personality traits, strengths, and weaknesses. Learn about the 5M Model, each of the five entrepreneurial styles in the model, and how they differ from each other. **Communicate Effectively:** Learn how incorrect assumptions and limiting our opinions about people can negatively impact our communication. Identify the barriers which cause communication breakdown, such as miscommunication and poor listening, and learn how to overcome them. **Communication Best Practices.** Understand the importance of listening in communication and learn to listen actively. Learn a few body language cues such as eye contact and handshakes to strengthen communication. (Practical Application)			**08 Hrs**
UNIT-V			
Design Thinking for Customer Delight: Understand Design Thinking as a problem-			**08 Hrs**

solving process. Describe the principles of Design Thinking. Describe the Design Thinking process. **Sales Skills to Become an Effective Entrepreneur:** Understand what is customer focus and how all selling effort should be customer-centric. Use the skills/techniques of personal selling, Show and Tell, and Elevator Pitch to sell effectively. **Managing Risks and Learning from Failures:** Identify risk-taking and resilience traits. Understand that risk-taking is a positive trait. Learn to cultivate risk-taking traits. (Practical Application) Appreciate the role of failure on the road to success, and understand when to give up. Learn about some entrepreneurs/risk-takers. (Practical Application). **Are You Ready to be an Entrepreneur:** Let's ask "WHY" Give participants a real picture of the benefits and challenges of being an entrepreneur. Identify the reasons why people want to become entrepreneurs. Help participants identify why they would want to become entrepreneurs.	

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.

Reference Books	
1.	Law Relating to Intellectual Property, Wadehra B L,5th Edition, 2012, Universal Law Pub Co. Ltd.-Delhi, ISBN: 9789350350300
2.	Intellectual Property Rights: Unleashing Knowledge Economy, Prabuddha Ganguly, 1st Edition, 2001, Tata McGraw Hill Publishing Company Ltd., New Delhi, ISBN: 0074638602.
3.	Intellectual Property and the Internet, Rodney Ryder, 2002, Lexis Nexis U.K., ISBN: 8180380025, 9788180380020.
4.	Entrepreneurship, Rajeev Roy, 1st Edition, 2012, Oxford University Press, New Delhi, ISBN: 9780198072638.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**1**	**-**	**-**	**-**	**3**	**3**	**-**	**3**	**1**	**2**	**-**	**3**
CO2	**1**				**3**	**3**	**3**	**3**	**1**	**2**	**-**	**3**
CO3	**-**	**3**	**2**	**-**	**-**	**2**	**2**	**3**	**3**	**3**	**3**	**3**
CO4	**-**	**3**	**2**	**-**	**-**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Low-1 Medium-2 High-3

Semester: VI		
MICROBIAL BIOTECHNOLOGY (Theory)		
Course Code: 16BT62		**CIE Marks: 150**
Credits: L:T:P:S: 3:0:1:1		**SEE Marks: 150**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Apply the basic techniques of genetic engineering in the field of microbial biotechnology.
2	Develop methodology for the isolation and screening of recombinants.
3	Develop the fermentation processes for the production of foods, beverages, amino acids, vitamins and antibiotics.
4	Describe the role of microorganisms in mineral recovery and alternative fuel production.

Unit-I	
Introduction to Microbial Biotechnology: Scope and Applications of Microbial Biotechnology, Microbial Production flow sheet, Microbial biomass, Microbial Enzymes, Microbial Metabolites and recombinant products. Isolation of industrially important microorganisms, preservation techniques of microbes, Strain development by various methods and isolation of fermentation products.	**07 Hrs**
Unit – II	
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**.**	**07 Hrs**
Unit -III	
Microbial products 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 Mushroom.	**07 Hrs**
Unit –IV	
Microbial production of primary and secondary metabolites: Amino acids (glutamic acid and lysine), vitamins (B12, riboflavin and carotenoids), Antibiotics (β lactams, aminoglycosides, macrolides and tetracyclines)- Improving antibiotic production**.**	**07 Hrs**
Unit –V	
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).	**08 Hrs**
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.** Determination of order and rate constant in a continuous stirred tank reactor. **9.** Residence time distribution studies in plug flow reactor. **10.** Residence time distribution studies in continuous stirred tank reactor.	

Self-study topics:

1: CFD applications in Microbial Processes.
2: MiniTab Utilization for Optimization.

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 using bioreactor.
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 condition.

Reference Books	
1	Glazer, A. N. and H. Nikaido; Microbial Biotechnology; Fundamentals of Applied Microbiology. Cambridge University Press; 2 edition, 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.

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Theory – 100 Marks

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Laboratory- 50 Marks

The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150

Theory – 100 Marks

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Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	-	-	2	3	-	-	-	-	-	-	-
CO2	3	3	3	3	3	3	-	-	-	-	-	2
CO3	3	3	2	3	3	2	1	3	2	-	-	-
CO4	L	2	3	3	-	3	3	-	-	-	-	-

High-3: Medium-2: Low-1

Semester VI		
PROCESS DYNAMICS & CONTROL (Theory and practice)		
Course Code: 16BT63		**CIE Marks: 150**
Credits: L:T:P:S: 3:0:1:1		**SEE Marks: 150**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Formulation of dynamic models based on fundamental laws.
2	Understand the different modes of control system, components of control system and analyze the response of controllers for various types of inputs.
3	Solve linear dynamic models of first and second order systems.
4	Determine the stability of a closed-loop feedback control system and know how to tune a single-loop controller for better response.

Unit-I	
First order systems: Laplace transforms: Laplace transformation of standard functions, derivatives and integrals, inversion. Transfer functions, forcing functions, transient response, physical examples of first order systems: mercury in glass thermometer, liquid level system, mixing process in tanks and stirred tank reactors. Linearization of non-linear I order systems. **Response of first order system in series:** interacting and non-interacting systems.	**07 Hrs**
Unit – II	
Second order systems: Terms of second order under damped process, examples of second order systems: U-tube manometer, Damped vibrator, Under damped, critically damped and over damping, transient response, Transportation lags.	**07 Hrs**
Unit -III	
Controllers: Controllers, components of a control system, closed loop and open loop control systems, transfer functions for two position, proportional, Proportional+Reset (P+I), Proportional + Rate (P+D), Proportional + Reset +Rate controller(P+I+D). **Final Control element:** actuators, valve body, valve characteristics.	**07 Hrs**
Unit –IV	
Closed loop systems: Control System, servo and regulator problem, Overall transfer function for single-loop systems and multiloop control system, overall transfer function for set-point change and load change. Lumped and distributed parameter system. Transient response of simple control systems	**08 Hrs**
Unit –V	
Stability: Concept of Stability, Stability criterion, Routh Herwitz test for stability, Root Locus method. **Frequency Response:** Bode diagrams for first, second order, systems and controllers, Bode stability criterion, Ziegler-Nichols tuning of controller settings.	**07 Hrs**
LAB EXPERIMENTS	
1.Time constant determination and response to step change of Thermometer: First order 2. Single tank system: First order 3. Non interacting First order elements in series 4. Interacting First order elements in series 5. U tube manometer: II order system 6. Characteristics of thermistors and RTD studies 7. Determination of pH in a process. 8. Flow controller (P, I, D, PID controllers) 9. Pressure controller (P, I, D, PID controllers) 10. Control valve characteristics 11. Temperature controller (P, I, D, PID controllers) 12. Controller tuning	

Self Study:

1. Formulation of dynamic models of realistic processes.
2. Evaluation of dynamic behaviour of linear first-order systems and compare with the experimental results.

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand and write the transfer functions for First and second order systems
CO2:	Analyze the response of first order, second order and controllers for various types of forcing functions
CO3:	Develop overall transfer function for closed loop control systems
CO4:	Evaluate the stability of the control systems and know the design of modern hardware and instrumentation needed to implement process control.

Reference Books	
1	Steven E.LeBlanc and Donald R. Coughanour; Process System Analysis and Control; McGraw Hill, New Delhi, 3rdEdition, 2009, ISBN-978- 0073397894.
2	R.P.Vyas; Process Control and Instrumentation; Denett & Company, 4thEdition, 2010, ISBN 978-8189904050.
3	Luyben; Process Modeling, Simulation and Control for Chemical Engineers; McGraw Hill, 2ndEdition, 1990; ISBN-978-0071007931.
4	D.G.Peacock, J.F.Richardson; Coulson and Richardson's Chemical Engineering; vol 3, Pergamon Press, 3rdEdition, 2006, ISBN 978-8131204528.

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Theory – 100 Marks

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CO1	3	3	-	-	2	-	-	-	-	-		
CO2	3	3	-	-	-	-	-	-	-	-	-	-
CO3	3	3	3		2	-	-	-	--	-	-	--
CO4	3	3	2	2	3	2	-	-	1	-	--	-

High-3: Medium-2: Low-1

Semester: VI		
GENOMICS AND PROTEOMICS		
Course Code: 16BT64		**CIE Marks: 100**
Credits: L:T:P:S: 3:1:0:0		**SEE Marks: 100**
Hours: 36L +24T		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Understand the molecular aspects of the genome.
2	Develop the concepts and principles underlying the human genome project and other genome program.
3	Differentiate between the different structures and functions of the proteome.
4	Identify genetic markers for breeding purposes.

Unit-I	
Introduction: Eukaryotic genes and Polymorphisms: Organization of eukaryotic (microbial, plant and animal genomes) within nucleus, transcription, post transcriptional modification, translation, post translational modification and Inheritance pattern. Mitochondrial and chloroplast genome. Polymorphism. C-Values of eukaryotic genomes.	**06 Hrs**
Unit – II	
Sequencing and genome projects: Early sequencing efforts, Methods of preparing genomic DNA for sequencing, **Sequencing strategies**: shot-gun approach, clone contig approach, **DNA sequencing methods:** Gilbert and Maxim, Sanger Dideoxy method, Fluorescence method, High throughput sequencing. **Major genome sequencing projects:***E.coli, Saccharomyces cerevicea*, rice, *Arabidopsis thaliana*, *Drosophila melanogaster, Caenorhabditis spp* for human disease and drug targets.	**07 Hrs**
Unit -III	
Genomics: Expressed sequenced tags (ESTs) - Human disease & drug targets. Gene variation & Single Nucleotide Polymorphisms (SNPs) - drug discovery, disease association, diagnostic genes, comparative genomics. **Functional genomics:** Finding genes in the genome, assigning functions to the gene. **Genotyping** – DNA chips and diagnostics assays, RT-PCR, SAGE & DD-PCR. Importance of non coding sequences – miRNA and RNAi.	**07 Hrs**
Unit –IV	
Genome analysis: Molecular markers in genome analysis, principal classes of markers: Repetitive and coding sequences. DNA Fingerprinting - RFLPs & AFLPs. DNA amplification markers RAPDs, SCAR, microsattelites – simple sequences repeats (SSR) and inter simple sequence repeats (ISSR), Allozymes and Isozymes, Telomerase as molecular markers, FISH-DNA amplification markers. Types of mapping and their usefulness to plant and animal breeding.	**08 Hrs**
Unit –V	
Proteomics: Methods of protein isolation, purification and quantification, protein separation in 2-DE, staining of 2DE gels, Image analysis of 2DE gels, **Analysis of proteins**: High throughput proteome analysis by stable isotope labelling. Mass-spec based protein analysis, **Protein – proteininteractions:**C0- Immuno precipitation, Y2H and its variants, protein chip interaction detection techniques, Applications of proteome analysis to drug development.	**08 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand and remember the concepts of various genes and their expression.
CO2:	Apply various large scale sequencing methods for sequencing various organisms genome.
CO3:	Acquire and evaluate the methods involved in analysis of genome and proteome.
CO4:	Develop or create a diagnostic tool for plant, animal and human diseases.

Reference Books	
1	Genome analysis and Genomics- S.B Primrose and R M Tayman, Wiley-Blackwell 3rd Ed., 2002 ISBN: 978-1-4051-0120.
2	D.C Liebler; Introduction to Proteomics; Humana Press; 2002; ISBN: 0896039927.
3	B Lewis; Genes X; Jones and Bartlett publications; 9th edn; 2011; ISBN: 9780763766320
4	Savithri Bhat; Genomics; Duckworth Press; 1st edn; 2007; 1st edn;ISBN: 978819046991

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	-	-	-	-	-	-	-	-	-	-	-
CO2	1	3	3	2	1	-	-	-	-	-	-	-
CO3	3	3	3	1	3	-	-	-	-	-	-	-
CO4	1	3	3	1	3	-	-	-	-	-	-	-

High-3: Medium-2: Low-1

Semester: VI		
CLINICAL TECHNOLOGY **(Group C: Professional Core Elective)**		
Course Code: 16BT6C1		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:1		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Study cell and tissue culture techniques relate to healthcare
2	Provide framework in which clinical technology can be understood in the field of science and technology
3	Learn to use electronic tools for development of clinical records, ehealth and ethics.
4	Know fundamental methods used to facilitate the integration of software and hardware development for variable and mobile health monitoring system.

Unit-I	
Stem Cells: Concepts and Types of Stem cells: Embryonic, Adult and Induced. Embryonic stem cells: Pluripotent, Totipotent and Multipotent Cells. Adult stem cells, the tissue specific cells: Hematopoietic, Epidermal and Epithelial stem cell. Induced pluripotent stem cells. Cell culture methods, Cell isolation, selection, maintenance of primary and early passage cultures. Clinical potential of stem cells: Organ and tissue regeneration, cardiovascular treatment, Cell deficiency therapy, treatment of any brain related defects.	**07 Hrs**
Unit – II	
Tissue Engineering: History and scope of tissue engineering. The isolation and handling of human and animal tissue. The major methods of preparing a primary culture. Introduction to cell adhesion: cell–cell adhesion, cell–matrix adhesion and signalling, cell proliferation, and differentiation. Tissue engineering for tissue regeneration: using bone marrow mesenchymal stem cells (MSCs) and adipose derived stem cells (ASCs). Therapeutic strategy for repairing the injured spinal cord using stem cells. Wound and Disc repair using stem cells. Engineering of tissues: cartilage, bone and skin.	**07 Hrs**
Unit -III	
E-Health Record & Telemedicine: Technologies and sources of clinical and biomedical information in order to obtain, organise, interpret and convey clinical, scientific and health-related information; Consumer health informatics, transmission and maintenance of e-health records, Clinical decision support system (CDSS), features and characteristics of CDSS, Principles of telemedicine; implementation of the principles of telemedicine based on (the best) evidence. Real-time interactive telemedicine, Telenursing, Tele-pharmacy, Teletransmission of ECG, Teleradiology, Regulatory issues in telemedicine and respective practices in India, Framework of Health Information Technology (HIT).	**07 Hrs**
Unit –IV	
Wearable Health System: Architecture of wearable health monitoring systems (WHMS), WHMS hardware components, WHMS implementation walkthrough, Biosensors and Biosignals, wireless communication standards, wireless data transmission, commercially available WHMS, Research and development in WHMS, IT-based health management solutions, need of WHMS with embedded decision support, User-device interaction and system simulation.	**08 Hrs**
Unit –V	
Information security: client-server architecture, Health Information System (HIS) standards and framework, components of HIS, 360 degree patient centricity solutions, laboratory information system, clinical data repository, Primary and secondary data, importance of clinical data quality and standards, quantitative and qualitative analysis of medical records, clinical coding and data collection, clinical data and statistics, ethical issues in patient safety, understanding risk in patient safety research – social risk,	**07 Hrs**

psychological risk, economical risks; Risk assessment.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain type of stem cells, their properties and clinical applications.
CO2:	Apply cell culture/ tissue regeneration techniques to heal injured tissues.
CO3:	Illustrate the architecture of wearable health monitoring systems and its role in health management.
CO4:	Compare current practices of data collection with digital repository or clinical data, and risk involved & ethical issues.

Reference Books	
1	Pavlovic M and Balint B, Stem Cells and Tissue Engineering, Springer, 2012, ISBN-10-1461455049.
2	Cruz-Cunha MM, Tavares AJ and Simoes R, Handbook of research on developments in E-health and telemedicine: Technological and Social Perspectives (2 volumes), Medical Information Science Reference, 2009 ISBN-10-1615206701
3	Freshney RI, Culture of Animal Cells: A Manual of basic technique and specialized Applications, Wiley, 2011, ISBN: 9780470528129
4	Bonfiglio, Annalisa, De Rossi, Danilo (Eds.).2011. Wearable Monitoring Systems. ISBN 978-1-4419-7384-9

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	-	-	2	-	-	-	-	-	-	-
CO2	3	3	-	-	-	-	-	-	-	-	-	-
CO3	3	3	3		2	-	-	-	-	-	-	-
CO4	3	3	2	2	3	2	-	-	1	-	-	-

High-3: Medium-2: Low-1

Semester: VI		
FOOD ENGINEERING **(Group C: Professional Core Elective)**		
Course Code: 16BT6C2		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:1		**SEE Marks: 100**
Hours: 35L		**SEE Duration: 3Hrs**

Course Learning Objectives:

1	Get an insight of food processes namely pasteurization, blanching, sterilization ,extrusion processes
2	Understand the principles of evaporation, drying and freezing techniques
3	Learn about the advances in thermal and non thermal methods of food processing
4	Able to understand the principle and working of techniques of instruments used in food analysis and sensory evaluation and get an overview of packaging of food materials, design of packaging material and innovative techniques of food packaging

Unit-I	
Food Processing Systems: Basic principles of pasteurization, blanching, sterilization, extrusion processes. Ultra high pressure systems and pulsed electric fields. Microbial survivor curves, influence of external agents, thermal death time. General method for process calculation for Pasteurization, sterilization and aseptic processing and packaging. numericals.	**06 Hrs**
Unit – II	
Food Preservation Methods: Basic principle of evaporator and types (natural circulation, rising film, falling film, agitated thin film evaporators). Basic principles of dryer and types (Tray, tunnel, fluidized bed and spray dryers). Food freezing systems- direct and indirect contact systems, frozen food properties (density, thermal conductivity, enthalpy, specific heat thermal diffusivity), freezing time calculation.	**07 Hrs**
Unit -III	
Advances in food processing: Techniques both thermal and non-thermal.Newer techniques in thermal processing - Retort processing, UHT, Extrusion - hot and cold Ohmic heating, pulsed electric field, high-intensity light pulses, radio-frequency heating, microwave, thermo-sonication, modified atmosphere, enzymic processing and hurdle technology. Advanced Membrane Technology for water and liquid foods and effluent treatment. Application of Microwave for food cooking, dehydration. High hydrostatic processing of foods.	**08 Hrs**
Unit –IV	
Modern Techniques in Food Analysis and Sensory Evaluation: Application of modern techniques including spectroscopy, chromatography including GC, GC –MS, HPLC, HPTLC, gel permeation, ion-exchange, etc. Enzymes in food analysis; Supercritical fluid extraction in food analysis; Rapid methods for detection of food pathogens, biosensors, automation and use of computers in food analysis. Sensory evaluation – different scales, training, skills and importance for consumer acceptance, Quantification of sensory attributes - Artificial Tongue, Artificial Nose.	**08 Hrs**
Unit –V	
Food packaging: Packaging as a method for conservation of foods: Packaging materials and their physico-chemical characteristics. RTE frozen foods with reference to packaging. Evaluation of quality of packaging materials; Package design; Test procedures for packages; Cushioning materials; Selection of packaging materials and package design for food products; Prepackaging. Packaging materials for newer techniques like radiation processing, microwave and radio wave processing, high pressure processing, modified atmosphere and thermal processing as retortable pouches; Biodegradable packaging.	**06 Hrs**

Self-study topics

1. Food preservation methods to increase shelf life
2. Tools and techniques for food analysis, sensory evaluation and packaging

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand and remember the principles of food processing and preservation methods
CO2:	Apply the knowledge of freezing to calculate food freezing time and understand advanced food processing applications.
CO3:	Analyze the problems and do the calculations involved in pasteurization, sterilization and aseptic processing and packaging
CO4:	Evaluate the instrumentation techniques of food analysis, sensory analysis and food packaging materials characteristics

Reference Books	
1	R. Paul Singh and Dennis R. Heldman, Introduction to Food Engineering, Academic Press, Elsevier, 5th ed., 2013.ISBN 9780123985309
2	Fellows, P.J, Food processing Technology: Principles and Practice, Woodhead Publishing limited, Cambridge, 2nd edition, 2009. ISBN 978-1-84569-216-2
3	Sablani S., Rahman M, Handbook of Food and Bioprocess Modeling, CRC press, 1st ed., 2006.ISBN 9780824726713
4	Romeo T. Toledo, Fundamentals of Food Process Engineering, Springer, 3rd ed., 2007. ISBN-13: 978-0-387-29019-5

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	1	1	1	1	1	-	-	-	-	-	2
CO2	1	3	2	1	1	1	-	-	-	-	-	2
CO3	2	2	2	1	1	1	-	-	-	-	-	2
CO4	2	1	3	1	1	1	-	-	-	-	-	2

High-3: Medium-2: Low-1

Semester: VI		
FERMENTATION TECHNOLOGY **(Group C: Professional Core Elective)**		
Course Code: 16BT6C3		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:1		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives:

1	Develop the conceptualization for production of industrial biotechnological products by using industrial microbes and raw materials.
2	To design the fermentor for the growth of culture.
3	To develop the production flow sheet for primary, secondary and recombinant products.
4	To comprehend different process controllers involved in the fermentation process.

Unit-I	
INTRODUCTION: Background of fermentation- historical review. Fermentation as a Biochemical process, Microbial biomass, Enzymes, Metabolites recombinant products, general flow sheet for microbial fermentation. **Microbes:** Isolation of industrially important microorganisms, preservation techniques of microbes, Strain development for primary, secondary and recombinants, Mode of operation: batch, fed batch and Continuous.	**07 Hrs**
Unit – II	
Raw Materials and Sterilization: Selection of typical raw materials, Different media for fermentation, Optimization of media, Different sterilization methods – batch sterilization, continuous sterilization, filter sterilization. **Preparation of Inoculum:** Introduction to media preparation, nutrient requirements of the cell, Inoculum preparation from laboratory scale to pilot scale and large scale fermentation, maintenance of aseptic conditions.	**07 Hrs**
Unit -III	
Design of Fermenters: Basic structure of fermenter, body construction and space requirements. Description of different parts of fermenter and types of fermenters. Process Control: Instruments involved in the fermentation: flow rate, temperature, pH, Dissolved oxygen and pressure. Foam sensing and control. Online analysis for substrate and biomass estimation. Computer based data acquisition-SCADA.	**07 Hrs**
Unit –IV	
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-major factors involved in scaling up and its aeration/agitation regimes in stirred tank reactor and scale down aspects in design of laboratory experiment.	**07 Hrs**
Unit –V	
Industrial Operations: Effluent treatment: Characteristics of effluent from fermentation industries- brewery, antibiotics and organic acids. Methods of Treatment and Disposal: treatment process- aerobic and anaerobic treatment, byproducts. **Economic Aspects:** Economy of fermentation, market potential. Legalization of products like antibiotics and recombinants.	**08 Hrs**

Self-study topics:

1. Scale-Down and Scale-Up strategies for Recombinant products.
2. Reactor Design-Agitated, Hallow, Air Bubble, Packed bed and Immobilized Reactor.

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember and understand the processes for isolating the industrial important microorganism for production various biotechnological products.
CO2:	Implement the techniques for fermentation Process and its parameters Optimization.
CO3:	Analyze the scale up techniques, process economics and effluents management.
CO4:	Design fermenter and its accessories involved in the process.

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.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	-	3	2	-	-	-	1	-	-	-
CO2	2	2	3	1	3	-	-	-	-	-	-	-
CO3	1	3	3	3	2	-	3	1	1	-	-	1
CO4	2	2	3	3	3	-	-	-	2	-	-	-

High-3: Medium-2: Low-1

Semester: VI		
JAVA and J2EE **(Group C: Professional Core Elective)**		
Course Code: 16BT6C4		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:1		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives:

1	Explore conceptually programming applications in the domains of Life sciences and in general study the role of computer science in life sciences
2	Acquire knowledge of the Object Oriented Programming and Advanced programming skills in Java
3	Study Threading, Event management, Database connectivity as well as Web programming in Java
4	Understand the importance of Threading, Event management, Database connectivity as well as Web programming to High throughput Data analysis

Unit-I	
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.	**07 Hrs**
Unit – II	
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. Event handling for Buttons, Text boxes, List boxes, radio buttons, Check boxes, slide bars and menu options.	**07 Hrs**
Unit -III	
Applets: The Applet Class: Two types of Applets, Applet basics, Applet Architecture, An Applet skeleton; The HTML APPLET tag; Passing parameters to Applets, Simple Applet display methods; Requesting repainting; Using the Status Window. getDocumentbase() and get Codebase(); ApletContext and show Document(); The Audio Clip Interface; The Applets tub Interface; Drawing Lines; Drawing Other Stuff; Color; Mouse Input; Keyboard Input and Output to the Console. Threads and Animation, Backbuffers, Graphics and Painting.	**07 Hrs**
Unit –IV	
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; Result Set; 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.	**07 Hrs**
Unit –V	
BioJava: Working with Nucleic Acid and Protein Sequences – create, read, compare sequences. Working with Protein Structures – fetching, parsing PDB structures, Calculating structure	**08 Hrs**

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:	Analyze 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	Herbert Schildt , Java - The Complete Reference, 9th Edition, 2014, ISBN: 0071808558
2	John Hunt, Chris Loftus, Guide to J2EE: Enterprise Java, Springer Science & Business Media, 2012, ISBN – 9781447100171.
3	Joyce Farrell, Java Programming, Cengage Learning, 8th Edition, 2015, ISBN - 9781305480537
4	Buyya, Java The Complete Reference, 8th Edition, McGraw Hill Professional, 8th Edition, 2011, ISBN - 9780071606318

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	1	2	2	3	3	-	-	1	1	-
CO2	3	3	3	3	3	3	1	-	2	-	-	-
CO3	3	2	2	2	1	2	3	-	-	-	2	-
CO4	2	3	3	3	3	1	2	-	-	-	-	-

High-3: Medium-2: Low-1

Professional Elective D

Semester: VI		
MEDICAL INSTRUMENTATION **(Group D: Professional Core Elective)**		
Course Code: 16BT6D1		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 42L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	To study the source of bioelectric signals, propagation of action potential, their transduction and biomedical application
2	To give an insight into the working principle of instruments of cardiovascular measurement, oxymetry and audiometry
3	To understand the applications of imaging such as X-ray, MRI I and ultrasonics n medical diagnostics
4	To get an idea of therapeutic applications of pacemakers, defibrillators, stimulators and diathermy.

Unit-I	
Introduction To Medical Instrumentation: Sources of biomedical signals, basics of medical instrumentation system, different bioelectrical signals. Transducers: Definition, classification and biomedical application. Bio-potential Electrodes, Resting and Action potential, Propagation of Action potential, bioelectric potentials.	**08 Hrs**
Unit – II	
Cardiovascular Measurements: Anatomy of heart, cardiac cycle, Measurement of blood pressure, characteristics of Electrocardiogram (ECG) and its Block diagram description, lead configuration and recorders. Blood flow meters, electromagnetic, ultrasonic, NMR and laser Doppler blood flow meters. **Biotelemetry:** wireless telemetry, single channel / multi channel telemetry. Implantable telemetry for ecg & temperature, blood pressure / flow.	**08 Hrs**
Unit -III	
Blood gas analyzers: pCO2, pO2, Complete blood gas analyzer, Commercial blood gas analyzer, Pulse oxymetry. In vitro, in-vivo, transmission, ear, fingertip oxymetry, skin reflectance oxymetry. **Blood cells counters:** methods of. – microscopic, coultercounter. Audiometers: Mechanism of hearing, requirements of audiometer, calibration of audiometer. Biological effects of radiofrequency and microwave fields	**08 Hrs**
Unit –IV	
Diagnostic And Medical Imaging System: X-Ray: general principles of Imaging, Instrumentation: collimators, X-Ray intensifying Screen, X-ray films. Special imaging techniques for X-rays. Magnetic Resonance imaging (MRI): general principles of MRI, Instrumentation, Magnet design, Magnet field gradient coils, radiofrequency coils, MR Imaging, Clinical application of MRI.	**09 Hrs**
Unit –V	
Therapeutic Equipment's: 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, Single- Crystal transducers, Diagnostics scanning modes, Biological effect of ultrasound.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the sources of biomedical signals and instruments to measure them.
CO2:	Have knowledge of parameters to measure the heart function and conditions in which therapeutic equipments are to be used and precautions taken.
CO3:	Appreciate the limitations and potentials of non-invasive imaging systems in medical

	diagnostics
CO4:	Apply audiometry and oxymetry to measure hearing and blood gas concentration.

Reference Books	
1	Ananda natarajan .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, 2004.ISBN-9780071777469.
3	Shakti. Chatterjee, Aubert Miller. Biomedical Instrumentation Systems. Delmar cengage learning Pub.2010.ISBN:13-978-1418018-665 Mandeep Singh. Introduction to Biomedical Instrumentation. PHI Pub., 2010. ISBN: 9788120341630.
4	Ananda natarajan .R. Biomedical Instrumentation and Measurements. PHI Pub. 2011. ISBN: 978-81-203-4227-9.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	2	-	-	-	1	2	-	-
CO2	3	3	2	2	2	-	-	-	1	2	-	-
CO3	3	3	2	2	2	-	-	-	1	2	-	-
CO4	3	3	2	2	2	-	--	-	1	2	-	--

High-3: Medium-2: Low-1

Semester: VI		
FOOD AND DAIRY TECHNOLOGY (Group D: Professional Core Elective)		
Course Code: 16BT6D2		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 42L		**SEE Duration: 3Hrs**

Course Learning Objectives:

1	Understand concept of food and dairy along its intricacies for better utility
2	Utilize various components and assets of food for good health
3	Comprehend various techniques and tools for increasing shelf life of food
4	Apply the knowledge of various supplements and adjuvants along with packaging for healthier society.

Unit-I	
History and development of food biotechnology, Application of genetics to food production. Methods of molecular cloning, immobilization of microbial and cultured plant cells. Scope and importance of food processing: national and international perspectives, Principles of Preservation methods, fermentation methods for preservation, and chemical preservations of foods. Food preservation by low-temp: Refrigeration, freezing and freeze-drying. Food preservation by heating: drying, osmotic dehydration, blanching, canning, pasteurization, sterilization, extrusion cooking. Non-thermal preservation: Hydrostatic pressure, dielectric heating, microwave processing, hurdle technology, membrane technology, irradiation. retort processing, concentration and drying	**09 Hrs**
Unit – II	
Contaminants of foods-stuffs, vegetables, cereals, pulses, oilseeds, milk and meat during handling and processing. Biochemical changes caused by micro-organisms, deterioration and spoilage of various types of food products, microbial food fermentation Food poisoning and microbial toxins, standards for different foods. Food borne intoxicants and mycotoxins. Food contaminants, food toxicants. Naturally occurring toxic substances, protease inhibitors, bioactive components: phytates, polyphenols, saponins, phytoestrogens...	**08 Hrs**
Unit -III	
Water in food, water activity and shelf life of food. Natural food flavours and characterization. Pigments in food and their industrial applications. Energy value of foods. Pathways of metabolism of carbohydrates, proteins, lipids. Enzyme biosynthesis and regulation. Metabolic regulation, Release of energy and its trapping. Metabolic rate and caloric needs, RDAs. Nutrition of dietary fibres. Additives in food processing and preservation. Various additives such as preservatives, antioxidants, emulsifiers, sequesterants, humectants, stabilizers. Colours, flavours, sweeteners, acidulants..	**09 Hrs**
Unit –IV	
Composition of milk, processing of market milk, toning of milk, homogenization, pasteurization, sterilization, storage, transportation and distribution of milk. Milk product processing-cream, butter, condensed milk, evaporated milk, whole and skimmed milk powder. Instantization of milk and milk products, Fermented milk products. Dairy equipments and sanitization. Pasteurisation, sterilization, HTST and UHT processes, Substitutes for milk and milk products. Casein, lactose and other by-products, Weaning foods, therapeutic foods; Fortification and enrichment; Traditional dairy products. Milk confections. Toning of milk, Judging and grading of milk and its products. In-plant cleaning system.	**08 Hrs**
Unit –V	
Introduction to packaging. Basic packaging materials and their properties, types of packaging, packaging design, packaging for different types of foods, Deteriorative changes in foodstuff and packaging methods for prevention, shelf life of packaged foodstuff, methods to extend shelf-life. Retort pouch packing, Biodegradable packaging. Active	**08 Hrs**

packaging. Importance and functions of quality control. Methods of quality, assessment of food materials, Sanitation and hygiene, GMP, GLP, Statistical quality control. Food laws and standard, Food Safety and Standards Act India 2006, Prevention of Food Adulteration Act, India, 1954, PFA, AGMARK. Concept of Codex Almentarious/ /USFDA/ISO 9000 series. Food adulteration and food safety. HACCP, Sensory evaluation, Refractometry, Rheology measurements. consumer protection, food audit.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the food and dairy components in detail for the healthier society under monitoring and control
CO2:	Analyse the various components of food and food safety
CO3:	Apply the knowledge of tools techniques for preservation of dairy, dry and other food assets
CO4:	Evaluate the significance of food components and its packaging with standards and regulations for the societal benefits

Reference Books	
1	Selia, dos Reis Coimbra and Jose A. Teixeir 2016 "Engineering Aspects of Milk and Dairy Products" , CRC Press, , ISBN: 1420090399, 9781420090390
2	Parker R. 2003. Introduction to food science. Albany NY: Delmar. 636 p. TP 370 P33 2003
3	Vaclavik VA and Christian EW. 2014Essentials of food science, 4thed. New York NY: Springer. ISBN 978-1-4614-9137-8.
4	Batty, J.C. and Folkman, S.L. 1983. Food Engineering Fundamentals. John Wiley and Sons, New York. 9780471056942

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

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CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	3	1	1	-	2	2	1	-	2
CO2	2	3	3	3	3	2	3	2	3	1	-	3
CO3	1	3	3	2	2	3	3	3	2	2	1	2
CO4	2	2	3	1	1	3	3	3	2	3	2	3

High-3: Medium-2: Low-1

Semester: VI		
PLANT DESIGN & ECONOMICS **(Group D: Professional Core Elective)**		
Course Code: 16BT6D3		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 44L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Explore the technical feasibility, survey safety factors involved during design of biochemical plant.
2	To have knowledge of breakeven analysis, fixed and working capital investment, working production cost and fixed charges.
3	To apply economic concepts to solve biochemical engineering problems.
4	Study of the cost estimation and profitability analysis of a biochemical plant.

Unit-I	
Process design development: Technical feasibility survey, process design of projects, types of design, process development, process flow diagrams – qualitative, quantitative and combined detail, safety factors and considerations.	**08 Hrs**
Unit – II	
General design considerations: Plant location- Marketability of the product, availability of technology, raw materials equipment, human resources, land and utilities, site characteristics, waste disposal, government regulations & other legal restrictions, community factors and other factors affecting investment and production costs. Plant layout- type and quantities of product to be produced, health & safety considerations, new site development, transportation, future expansion etc. Plant operations and control– Instrumentation, maintenance, utilities, structural design, storage, materials handling.	**09 Hrs**
Unit -III	
Cost estimation: Cash flow for industrial operation, factors affecting investment and production costs. Break even analysis and sensitivity analysis, problems. Capital Investments: Fixed capital investments, working capital investments, estimation of capital investment. Estimation of total product cost, Manufacturing costs: Direct production costs, fixed charges and plant overhead costs. Estimation of total product cost..	**09 Hrs**
Unit –IV	
Depreciation and interest: Depreciation and methods of determining depreciation, problems. Interests and investment costs, time value of money, income taxes.	**09 Hrs**
Unit –V	
Profitability analysis and Balance Sheets: Methods of evaluating profitability return on original investment, interest rate of return accounting for uncertainty and variations and future developments. Replacement and alternative investments. Financial statements, cash flow diagrams and Types of design report.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the concept of plant design and development the cost estimation for a chemical or biochemical industry that is essential for the feasibility study.
CO2:	Develop the flow sheet for qualitative and quantitative material flow.
CO3:	Calculate profitability and compare with the standard diagrams.
CO4:	Prepare the cost estimation and company balance sheet.

Reference Books	
1	T.R. Banga and S.C. Sharma; Industrial organization and Engineering Economics; Khanna Publishers; 24th edition; 2006; ISBN: 9788174090782
2	Peters M. and P. Timmerhaus; Plant Design and Economics for Chemical Engineers; Mc Graw Hill; 5thedition; 2002. ISBN-10:0072392665

3	D.F. Rudd and C.C. Watson; Strategy of Process Engineering; John Wiley; 1st edition; 1968; ISBN: 9780471744559
4	F.P.Helmus; Process plant design: Project management from inquiry to acceptance; Wiley-VCH; 1stedition; 2008; ISBN: 9783527313136

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	-	-	-	2	2			-	-	2
CO2	2	3	-	1	-	1	-	-	1	-	-	1
CO3	3	2	1	-	-	1	1	-	1	-	-	1
CO4	2	3	1	-	-		-	-	-	-	-	1

High-3: Medium-2: Low-1

Semester: VI		
SYSTEMS BIOLOGY **(Group D: Professional Core Elective)**		
Course Code: 16BT6D4		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 42L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	To define the field of systems biology and its sub-fields.
2	Identify large-scale methods used in systems biology research and their basic results.
3	Compare different systems biology approaches in their advantages and disadvantages.
4	Apply the knowledge of systems biology to give solution to practical issues.

Unit-I	
Introduction to Systems Biology: Scope, Applications. Concepts, implementation and application. A review of network concepts: properties and modeling of feedback/feed-forward systems. Databases for Systems Biology, Mass Spectrometry and systems Biology. Cell-to-Cell variability, stochastic gene induction, stochastic simulation. Fick's law, Local excitation and Global inhibition theory.	**09 Hrs**
Unit – II	
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, and flux balance analysis. 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. Modelling and Analysis of networks-mathematical and statistical methods used to evaluate and analyse large-scale data sets. Network Motifs..	**09 Hrs**
Unit -III	
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..	**09 Hrs**
Unit –IV	
Multiscale representations of cells and Emerging phenotypes: Multistability and Multicellurarity, 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.	**06 Hrs**
Unit –V	
Modeling Tools and applications: SBML, MathMLCellML, Petri Nets and Bioinformatics with case studies. Systems biology approaches to solve biological problems-case studies. Models for Eukaryotic Gradient Sensing. Rapid Pole-to-pole Oscillations in E. coli. Synthetic biology-concept and applications. The Systems Biology of Cancer, oncogenes, and p53 tumor suppressor. Gene Circuit Design (optimal expression of a protein in a constant, periodic and stochastic environment).	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the concepts, implementation and applications of systems biology.
CO2:	Apply genetic networks and models currently used in systems biology.
CO3:	Analyze modeling 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	Andres Kriete, Roland Eils. Computational Systems Biology. Academic Press, 2006.ISBN: 9780124059382.
2	Andrzej K. Konopka. Systems Biology. CRC, 2006.ISBN: 978-1-4200-1512-6.
3	CorradoPriami. Transactions on Computational Systems Biology I. Springer, Edition 2009.ISBN: 978-3-540-32126-2.
4	Fred C. Boogerd, H.V. Westerhoff. Systems Biology. Elsevier, Edition 2007. ISBN: 9780080475271

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	-	-	2	3	2	-	1	1	1	-
CO2	3	3	2	3	2	-	2	2	-	1	2	-
CO3	2	2	2	3	3	3	2	2	-	1	2	2
CO4	2	2	3	3	2	-	2	2	1	-	-	-

High-3: Medium-2: Low-1

Semester: VI		
BIOINSPIRED ENGINEERING (Group E: Global Elective)		
Course Code: 16G6E01		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	To familiarize engineering students with basic biological concepts
2	Utilize the similarities noted in nature for a particular problem to bring inspiration to the designer.
3	Explain applications such as smart structures, self-healing materials, and robotics relative to their bio logical analogs
4	To gain an understanding that the design principles from nature can be translated into novel devices and structures and an appreciation for how biological systems can be engineered by human design

Unit-I	
Introduction to Biology: Biomolecules-Proteins, carbohydrates, lipids and Nucleic acids. Cell types- Microbial, plant, animal.Organ system- Circulatory, digestive, respiratory, excretory and nervous system. Sense organs. Plant process- Photosynthesis.	**06 Hrs**
Unit – II	
Introduction to Biomimetics: Wealth of invention in nature as inspiration for human innovation: Mimicking and inspiration of nature- synthetic life. Nature as a model for structure and tools: Biological clock, honey comb as strong light weight structure. Materials and processes in biology- Spider web, honey bee as a multi-material producer, fluorescent materials in fire flies. Bird and insect as source of inspiring flight. Robotics as beneficiary for biomimetic technologies.	**08 Hrs**
Unit –III	
Biological materials in Engineering mechanisms: Introduction, Comparison of biological and synthetic materials: Silk processing and assembly by insects and spiders- High performance fibers from nature, Seashells- High performance organic and inorganic composites from nature. Shark skin- Biological approaches to efficient swimming via control of fluid dynamics, Muscles- Efficient biological conversion from chemical to mechanical engineering.	**08Hrs**
Unit –IV	
Biological inspired process and products: Artificial neural networks, genetic algorithms, medical devices. Biosensors. Plant as Bioinspirations: Energy efficiency, Biomimetic super hydrophobic surfaces- lotus leaf effect. Bionic leaf and Photovoltaic cells.	**08Hrs**
Unit –V	
Implants in Practice: Artificial Support and replacement of human organs- Introduction, Artificial kidney, liver, blood, lung, heart, skin and pancreas. Total joint replacements- Visual prosthesis -artificial eye. Sense and sensors: Artificial tongue and nose, Biomimetic echolation. Limitations of organ replacement systems.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember and explain the fundamentals of Biology

CO2:	Describe the basic principles of design in biological systems.
CO3:	Differentiate biological phenomena to support inspiration for visual and conceptual design problems
CO4:	Create engineered solutions to customer needs utilizing a variety of bio-inspiration techniques.

Reference Books	
1	Jenkins, C.H. Bioinspired Engineering, NY: Momentum press, 2012 ISBN: 97816066502259
2	C.C.Chatterjee, Human Physiology Volume 1 (11th Edition), 2016, ISBN 10: 8123928726 / ISBN 13: 9788123928722
3	Yoseph Bar-Cohen, Biomimetics: Biologically Inspired technologies, 2005, CRC press, ISBN: 9780849331633
4	Donald Voet, Charlotte W. Pratt. Principles of Biochemistry: International Student Version. Wiley John and Sons, 2012. ISBN: 1118092449.

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	1	1	1	1	1	1	1	2
CO2	2	1	2	1	1	1	1	1	1	1	1	2
CO3	3	3	3	2	1	1	1	1	1	1	1	3
CO4	3	3	3	1	1	1	1	1	1	1	1	2

High-3 : Medium-2 : Low-1

Semester: VI		
GREEN TECHNOLOGY (Group E: Global Elective)		
Course Code: 16G6E02		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Learn the tools of green technology
2	Know various forms of renewable energy
3	Study the environmental consequences of energy conversation
4	Understand energy audits and residential energy audit
5	Understand the application of green technology in various industries

Unit-I	
Current Practices and Future Sustainability: Need for green technology, fundamentals of energy and its impact on society and the environment, the mechanics, advantages and disadvantages of renewable energy sources, energy conservation and audits, zero waste technology, life cycle assessment, extended product responsibility, concept of atom economy, tools of Green technology **Cleaner Production:** Promoting cleaner production, benefits and obstacles of cleaner production, cleaner production technologies.	**07 Hrs**
Unit – II	
Solar Radiation and Its Measurement: Solar constant, solar radiation at the earth's surface, solar radiation geometry, solar radiation measurements **Applications of Solar Energy**: Introduction, solar water heating, space-heating (or solar heating of buildings), space cooling (or solar cooling of building), solar thermal electric conversion, agriculture and industrial process heat, solar distillation, solar pumping, solar cooking **Geothermal Energy:** Resource identification and development, geothermal power generation systems, geothermal power plants case studies and environmental impact assessment.	**08 Hrs**
Unit -III	
Energy From Biomass (Bio-Energy): Introduction, biomass conversion technologies, wet Processes, dry Processes, biogas generation, factors affecting biodigestion, types of biogas plants (KVIC model & Janata model), selection of site for biogas plant **Bio Energy (Thermal Conversion):** Methods for obtaining energy from biomass, thermal gasification of biomass, classification of biomass gasifiers, chemistry of the gasification process, applications of the gasifiers.	**07 Hrs**
Unit –IV	
Wind Energy: Introduction, basic components of WECS (Wind Energy Conversion system), classification of WEC systems, types of wind machines (Wind Energy Collectors), horizontal-axial machines and vertical axis machines. **Ocean Thermal Energy**: OTEC-Introduction, ocean thermal electric conversion (OTEC), methods of ocean thermal electric power generation, open cycle OTEC system, the closed or Anderson, OTEC cycle, Hybrid cycle **Energy from Tides**: Basic principles of tidal power, components of tidal power plants, operation methods of utilization of tidal energy, advantages and limitations of tidal power generation	**07 Hrs**

Unit –V	
Hydrogen, Hydrogen Energy: Introduction, methods of hydrogen production (principles only), storage transportation, utilization of hydrogen gas, hydrogen as alternative fuel for motor vehicle, safety and management, hydrogen technology development in India **Application of Green Technology:** Electronic waste management, bioprocesses, green composite materials, green construction technology **Sustainability of industrial waste management:** Case studies on cement industry, iron and steel industry, petroleum sectors, marble and granite industry, sugar industry	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Recall the fundamentals of various forms of energy
CO2:	Explain the principles of various forms of renewable energy
CO3:	Apply the concept of zero waste, atom economy for waste management
CO4:	Create a waste management plan incorporating tools of green technology in various industries

Reference Books	
1	Non-Conventional Energy Sources, G.D.Rai, 5th Edition, 2016, Khanna Publications, ISBN: 8174090738
2	Renewable Energy-Power for a Sustainable Future, Edited by Godfrey Boyle, 3rd Edition, 2012, Oxford University Press, ISBN: 9780199545339
3	Energy Systems and Sustainability: Power for a Sustainable Future, Godfrey Boyle, Bob Everett, and Janet Ramage, 2nd Edition, 2012, Oxford University Press, ISBN: 0199593744
4	Renewable Energy resources , John Twidell and Tony Weir, 3rd Edition, 2015, Routledge publishers, ISBN:0415584388

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Semester End Evaluation (SEE); Theory (100 Marks)

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Semester: VI		
SOLID WASTE MANAGEMENT (Theory)		
Course Code:16G6E03		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	Impart the knowledge of present methods of solid waste management system and to analyze the drawbacks.
2	Understand various waste management statutory rules.
3	Analyze different elements of solid waste management, design and develop recycling options for biodegradable waste by composting.
4	Identify hazardous waste, e-waste, plastic waste and bio medical waste and their management systems.

UNIT-I	
Introduction: Land Pollution. Scope and importance of solid waste management. Present solid waste disposal methods. Merits and demerits of open dumping, feeding to hogs, incineration, pyrolysis, composting, sanitary landfill. 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. **Collection and transportation of municipal solid waste:** Collection of solid waste-services and systems, Municipal Solid waste (Management and Handling) 2000 rules with 2016 amendments. Site visit to collection system.	**08 Hrs**
UNIT-II	
Composting Aerobic and anaerobic composting - process description, process microbiology, Vermicomposting, Site visit to compost plant, Numerical problems. **Sanitary land filling**: 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.	**08 Hrs**
UNIT-III	
Hazardous waste management: Definitions, Identification of hazardous waste, Classification of hazardous waste, onsite storage, collection, transfer and transport, processing, disposal, hazardous waste (Management and handling) rules 2008 with amendments. Site visit to hazardous landfill site	**06 Hrs**
UNIT-IV	
Bio medical waste management: Classification of bio medical waste, collection, transportation, disposal of bio medical waste, Bio medical waste (Management and Handling) rules 1998 with amendments. Site visit to hospital to see the collection and transportation system and visit to biomedical waste incineration plant.	**06 Hrs**
UNIT-V	
E-waste management: Definition, Components, Materials used in manufacturing electronic goods, Recycling and recovery integrated approach. E- waste (management and handling) rules 2011.Site visit to e- waste processing facility. **Plastic waste management:** Manufacturing of plastic with norms. Plastic waste management. Plastic manufacture, sale & usage rules 2009 with amendments.	**06 Hrs**

Course Outcomes: After completing the course, the students will be able to	
1	Understand the existing solid waste management system and to identify their drawbacks.
2	Analyze drawbacks in the present system and provide recycling and disposal options for each

	type of waste.
3	Distinguish Hazardous waste, Biomedical waste, E waste and to provide scientific management system.
4	Evaluate and monitor the Biomedical waste, Hazardous waste, E waste, Plastic and Municipal waste management as per the rules laid by Ministry of Environment & Forest.

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 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.	Electronic waste management, R.E. Hester, Roy M Harrison,, Cambridge, UK, RSC Publication, 2009, ISBN 9780854041121
4.	Municipal Solid waste (Management & Handling Rules) 2000. Ministry of Environment & Forest Notification, New Delhi, 25th Sept 2000 and 2016 amendments.
5.	Hazardous waste (management, handling) rules 2008.Ministry of Environment and Forest Notification, New Delhi, 25th February 2009.

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Semester End Evaluation (SEE); Theory (100 Marks)

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CO-PO Mapping

CO-PO Mapping												
CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
CO1	1	-	-	-	-	1	-	-	-	-	-	-
CO2	2	1	-	-	1	1	-	-	-	-	-	-
CO3	2	2	1	-	2	1	1	-	-	-	-	1
CO4	2	2	1	-	3	2	2	-	-	-	1	1

Low-1Medium-2 High-3

Semester :VI		
INTRODUCTION TO WEB PROGRAMMING (Group E : Global Elective)		
Course Code:16G6E04		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3 Hrs**

Course Learning Objectives: The students will be able to	
1	Understand the basic concepts used in web programming.
2	Learn the definitions and syntax of different web technologies.
3	Utilize the concepts of JavaScripts, XML and PHP.
4	Design and develop web pages which are quick, easy and well-presented using different techniques such as CSS,XML and JavaScripts.

UNIT-I	
Introduction to Web Concepts Fundamentals of Web, HTML 5 - Core HTML attributes, headings, paragraphs and breaks, divisions and centering, quotations, preformatted text, lists, horizontal rules, block-level elements, text-level elements.XHTML – 1: Internet, WWW, Web Browsers and Web Servers, URLs, MIME, HTTP, Security, the Web Programmers Toolbox. XHTML: Basic syntax, Standard structure, Basic text markup, Images, Hypertext Links.XHTML (continued): Lists, Tables, Forms, Frames.	**07 Hrs**
UNIT-II	
Cascading Style Sheets (CSS): Introduction, Levels of style sheets, Style specification formats, Selector forms, Property value forms, Font properties, List properties, Color, Alignment of text, The box model, Background images, The and tags, Conflict resolution. **The Basics of JavaScript:** Overview of JavaScript; Object orientation and JavaScript; General syntactic characteristics; Primitives, operations, and expressions; Screen output and keyboard input; Control statements	**09 Hrs**
UNIT-III	
JavaScript (continued): Object creation and modification; Arrays; Functions; Constructor; Pattern matching using regular expressions; Errors in scripts. **JavaScript and HTML Documents:** The JavaScript execution environment; The Document Object Model; Element access in JavaScript; Events and event handling; Handling events from the Body elements, Button elements, Text box and Password elements; The DOM 2 event model; The navigator object; DOM tree traversal and modification.	**09 Hrs**
UNIT-IV	
Dynamic Documents with JavaScript: Introduction to dynamic documents; Positioning elements; Moving elements; Element visibility; Changing colors and fonts; Dynamic content; Stacking elements; Locating the mouse cursor; Reacting to a mouse click; Slow movement of elements; Dragging and dropping elements. **Introduction to PHP:** Origins and uses of PHP; overview of PHP; General syntactic characteristics; Primitives, Operations and Expressions; Output; Control statements; Arrays; Functions; Pattern Matching; Form Handling; Files; Cookies; Session Tracking.	**06 Hrs**

UNIT-V	
XML: Introduction; Syntax; Document structure; Document Type definitions; Namespaces; XML schemas; Displaying raw XML documents; Displaying XML documents with CSS; XSLT Style sheets; XML processors; Web services.	**05 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1.	Understand and explore internet related concepts that are vital for web development.
CO2.	Apply HTML tags for designing static web pages and forms using Cascading Style Sheet.
CO3.	Utilize the concepts of XML, JavaScripts along with XHTML for developing web pages.
CO4.	Design and develop web based applications using JavaScripts, CSS, XHTML, PHP and XML.

Reference Books	
1.	Programming the World Wide Web – Robert W. Sebesta, 7th Edition, 2013,Pearson Education, ISBN-13:978-0132665810
2.	Web Programming Building Internet Applications , Chris Bates, 3rd Edition, , 2006, Wiley India, ISBN : 978-81-265-1290-4
3.	Internet & World Wide Web How to H program , M. Deitel, P.J. Deitel, A. B. Goldberg, 3rd Edition,2004, Pearson Education / PHI, ISBN-10: 0-130-89550-4
4.	Thomas A Powell, The Complete Reference to HTML and XHTML, 4th Edition, 2003, Tata McGraw Hill publisher. ISBN: 978-0- 07-222942- 4.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**1**	**-**	**2**	**-**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**1**
CO2	**-**	**-**	**2**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**
CO3	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**-**	**2**	**-**	**-**	**2**
CO4	**-**	**-**	**3**	**-**	**2**	**-**	**-**	**-**	**2**	**-**	**-**	**2**

Low-1 Medium-2 High-3

Semester: VI (Global Elective-E)			
AUTOMOTIVE ELECTRONICS **(Group D: Global Elective)**			
Course Code: 16G6E05			**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0			**SEE Marks: 100**
Hours:36L			**SEE Duration: 3Hrs**
Course Learning Objectives: The students will be able to			
1	Understand the application of principles of sensing technology in automotive field		
2	Apply control systems in the automotive domain		
3	Understand automotive specific communication protocols / techniques		
4	Analyze fault tolerant real time embedded systems		

UNIT-I	
Power Train Engineering and Fundamentals of Automotive: Fundamentals of Petrol, diesel and gas engines, electric motors and control systems. Basic Automotive System, System Components, Evolution of Electronics in Automotive. Alternators and charging, battery technology, Ignition systems. Working principles of various electronic components and accessories used in Automotive. Developments in existing engine forms and alternatives. Hybrid designs (solar power, electric/gasoline, LPG, CNG, fuel cells). Basic Transmission systems.	**08 Hrs**
UNIT-II	
Sensor Technologies in Automotive: In-vehicle sensors: Working principles, Characteristics, limitations and use within the automotive context of the following: Temperature sensing e g. coolant, air intake. Position sensing e.g. crankshaft, throttle plate. Pressure sensing e.g. manifold, exhaust differential, tyre. Distance sensing e.g. anti-Collision, Velocity sensing e.g. speedometer, anti-skid. Torque sensing e.g. automatic transmission. Vibration sensing e.g. Airbags. flow sensing and measurement e.g. fuel injection. Interfacing principles: Operation, topologies and limitations of all sensors covered in the above to in-vehicle processing or communications nodes. Use of Actuators: Types, working principle, Characteristics, limitations and use within the automotive context of each type.	**07 Hrs**
UNIT-III	
Automotive Control Systems: Control system approach in Automotive: Analog and Digital control methods, stability augmentation, control augmentation. Transmission control, System components and functions. Cruise control, traction control, actuator limiting, wind-up, gain scheduling, adaptive control. Special Control Schemes: Vehicle braking fundamentals, Antilock systems. Variable assist steering and steering control. Controls for Lighting. Wipers, Air conditioning /heating. Remote keyless Entry and Anti-theft System, Emission Course-system control. Control techniques used in hybrid system. Electronic Engine control: Motion equations, modeling of linear and non-linear systems, numerical methods, system responses Objective of Electronic Engine control. Spark Ignition and Compression Ignition Engines and their electronic controls. Engine management testing: Engine management system strategies and implementation. Simulation and implementation methods. Methods of improving engine performance and efficiency. Model Based Development (MBD) Technology. AUTOSAR: Objectives and Architecture.	**07 Hrs**
UNIT-IV	
Automotive Communication Systems: Communication interface with ECU's: Interfacing techniques and interfacing with infotainment gadgets. Relevance of internet protocols, such as TCP/IP for automotive applications. Wireless LANs standards, such as Bluetooth, IEEE802.11x. Communication protocols for automotive applications. Automotive Buses: Use of various buses such as CAN, LIN, Flex Ray. Recent trends in automotive buses (Such as OBDI1. MOST, IE, IELI.I, D2B and DSI). Application of Telematics in Automotive: Global Positioning Systems (GPS) and General Packet Radio Service (GPRS),	**07 Hrs**

for use in an automotive environment. Vehicle to Vehicle Communication Higher End Technology: Comparative Study and applications of ARM Cortex-Ascries/M-scries. ARM 9 and ARM11.	
UNIT-V	
Diagnostics and Safety in Automotive: Fundamentals of Diagnostics: Basic wiring system and Multiplex wiring system. Preliminary checks and adjustments, Self-Diagnostic system. Fault finding and corrective measures. Electronic transmission checks and Diagnosis, Diagnostic procedures and sequence. On board and off board diagnostics in Automotive. Safety in Automotive: Safety norms and standards. Passenger comfort and security systems. Future trends in Automotive Electronics.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Acquire the knowledge of automotive domain fundamentals and need of electronics in Automotive systems
CO2:	Apply various sensors and actuators for Automotive applications
CO3:	Analyze different control systems and communication interfaces used in automotive systems.
CO4:	Evaluate the performance of telematics Diagnostics and safety norms in Automotive Systems.

Reference Books	
1.	Understanding Automotive Electronics, Williams. B. Ribbens, 6th Edition, 2003, Elsevier science, Newness publication, ISBN-9780080481494.
2.	Automotive Electronics Handbook, Robert Bosch, 2004, John Wiley and Sons,
3.	Automotive Embedded Systems Handbook, Nicolas Navet, F Simonot-Lion, Industrial Information Technology Series, CRC press.
4.	Automotive Control Systems Engine, Driveline and vehicle, Uwekiencke and lars Nielsen, Springer, 2nd Edition, 2005, ISBN 0-387-95368X

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**1**	**2**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1**
CO2	**3**	**2**	**2**	**1**	**-**	**1**	**-**	**-**	**-**	**1**	**-**	**1**
CO3	**3**	**2**	**2**	**1**	**-**	**1**	**-**	**-**	**2**	**-**	**1**	**1**
CO4	**3**	**1**	**2**	**1**	**2**	**1**	**-**	**-**	**1**	**-**	**-**	**-**

Low-1 Medium-2 High-3

SEMESTER – VI		
INDUSTRIAL ELECTRONICS (Group E: Global Elective)		
Course Code: 16G6E06		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	Explain the working of the devices used in power electronic circuits in industrial applications
2	Analysing and designing power electronic circuits which handle the electrical energy efficiently and economically and Identify the typical practical problems with industrial exposure acquired
3	Use basic concepts of design and working of electronic circuits for conversion and control of electrical energy.
4	Apply the knowledge to work as part of teams on multidisciplinary projects and to discuss industrial problems with regard to application of Power Electronics.

Unit-I	
Power semi-conductor Devices and static characteristics: Construction, working & characteristics of MOSFET, SCR, IGBT. Comparison of Power BJT, MOSFET, SCR, IGBT. Turn on methods of Power BJT, MOSFET and IGBT. Design of R, R-C, and UJT (pulse train) Gate triggering methods of SCR.	08 Hrs
Unit-II	
Thyristor Dynamic characteristics, Specifications and Protection: Gate characteristics of SCR, Dynamic characteristics of SCR. Design of Snubber circuit for SCR, Line Commutation and Forced Commutation circuits with design, Gate protection & overvoltage protection of SCR.	**07 Hrs**
Unit-III	
Converters: Single Phase Controlled Convertor- Full wave Half and Fully controlled line commutated bridge converters, Derivation of average load voltage and current. Three phase converters – Six pulse converters- with R load- Active inputs to the convertors with and without Freewheeling diode, Derivation of average load voltage and current. **Converter applications:** Industrial Applications of Half and Fully controlled converters to DC drives (Control of DC drives)	06 Hrs
Unit-IV	
Choppers – Step down, Step up Chopper, Step up/Down Chopper, Time ratio control and Current limit control strategies –Derivation of load voltage and currents with R, RL of Step down, Step up Chopper, Step up/Down Chopper – load voltage expression. Application of choppers to subway cars, Industrial drives , battery operated vehicles.	**07 Hrs**
Unit-V	
Classification of Choppers and Applications: Type A, Type B, Type C, Type D, Type E choppers and their industrial Applications, AC Chopper –phase control type. Inverters – Single phase inverter – Basic series inverter – Basic parallel Capacitor inverter, bridge inverter(single phase) – Voltage control techniques for inverters Pulse width modulation techniques. – UPS-online, offline (Principle of operation only	**08 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the comprehensive working of different devices and their applications.
CO2:	Analyze the application of skills in controlling and conversion of electrical energy.
CO3:	Evaluate and distinguish the performance of converters and inverters.

CO4:	Ability to implement their knowledge and skills in design of applications.

Reference Books	
1.	Power Electronics, M. D. Singh & K. B. Kanchandhani, Tata Mc Graw – Hill Publishing company, ISBN : 978-0-07-058389-4, 2008
2.	Power Electronics : Circuits, Devices and Applications, M. H. Rashid, Prentice Hall of India, 2nd Edition, ISBN : 0131228153, 9780131228153, 2004
3.	Power Electronics, P.C. Sen, Tata McGraw-Hill Publishing, ISBN: 978-0-07-462400-5, 2008.
4	Power Electronics P S Bimbra P.S Bimbra ,Khanna Publication ,ISBN:978-7409-279-3,5th Edition.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping															
CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	2	1	2	2	1	1	2	0	1	3	2	2
CO2	3	2	2	3	3	0	1	0	0	0	2	1	3	2	2
CO3	3	2	2	3	2	2	0	1	0	0	1	2	3	2	2
CO4	3	3	3	3	2	3	2	0	1	0	0	1	3	3	3

High-3: Medium-2: Low-1

VI Semester		
PROJECT MANAGEMENT **(Group E: Global Elective)**		
Course Code : 16G6E07		**CIE Marks : 100**
Credits : L: T: P: S:3:0:0:0		**SEE Marks : 100**
Hours : 33L		**SEE Duration : 03 Hrs**

Course Learning Objectives: The students will be able to	
1.	To understand the principles and components of project management.
2.	To appreciate the integrated approach to managing projects.
3.	To explain the processes of managing project cost and project procurements.

Unit – I	
Introduction: What is project, what is project management, relationships among portfolio management, program management, project management, and organizational project management, relationship between project management, operations management and organizational strategy, business value, role of the project manager, project management body of knowledge.	**06 Hrs**
UNIT – II	
Organizational influences & Project life cycle: Organizational influences on project management, project state holders & governance, project team, project life cycle. **Project Integration Management:** Develop project charter, develop project management plan, direct & manage project work, monitor & control project work, perform integrated change control, close project or phase.	**08 Hrs**
UNIT – III	
Project Scope Management: Project scope management, collect requirements define scope, create WBS, validate scope, control scope. **Project Time Management:** Plan schedule management, define activities, sequence activities, estimate activity resources, estimate activity durations, develop schedule, control schedule.	**07 Hrs**
UNIT – IV	
Project Cost management: Project Cost management, estimate cost, determine budget, control costs. **Project Quality management:** Plan quality management, perform quality assurance, control quality.	**06 Hrs**
UNIT – V	
Project Risk Management: Plan risk management, identify risks, perform qualitative risk analysis, perform quantitative risk analysis, plan risk resources, control risk. **Project Procurement Management:** Project Procurement Management, conduct procurements, control procurements, close procurement.	**06 Hrs**

Course Outcomes: After going through this course the student will be able to	
CO1	Understand the concepts, tools and techniques for managing large projects.
CO2	Explain various sub processes in the project management frameworks.
CO3	Analyze and evaluate risks in large and complex project environments.
CO4	Develop project plans for various types of organizations.

Reference Books:
1. A Guide to the Project Management Body of Knowledge(PMBOK Guide), Project Management Institute, 5th Edition, 2013, ISBN: 978-1-935589-67-9
2. Project Planning Analysis Selection Financing Implementation & Review, Prasanna Chandra, 7th Edition, 2010, Tata McGraw Hill Publication, ISBN 0-07-007793-2.
3. Project Management A System approach to Planning Scheduling & Controlling, Harold Kerzner, 10th Edition, 2009, CBS Publishers and Distributors, ISBN 047027806.
4. Strategic Project Management Made Simple: Practical Tools for Leaders and Teams, Terry Schmidt, 1st Edition, 2009, John Wiley & Sons, ISBN: 978-0470411582

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2											
CO2	2	2		1	1							
CO3							1	1				
CO4	2		3		1							

Low-1 Medium-2 High-3

VI Semester		
VIRTUAL INSTRUMENTATION (Group E: Global Elective)		
Course Code:16G6E08		**CIE Marks: 100**
Credits/Week: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours:35L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	Understand the difference between conventional and graphical programming, basic data acquisition concepts.
2	Differentiate the real time and virtual instrument.
3	Develop ability for programming in LabVIEW using various data structures and program structures.
4	Analyze the basics of data acquisition and learning the concepts of data acquisition with LabVIEW.

UNIT-I	
Graphical Programming Environment: Basic of Virtual Instrumentation, Conventional and Graphical Programming. Introduction to LabVIEW, Components of LabVIEW and Labels. **Fundamentals:** Data Types, Tool Pallets, Arranging Objects, Color Coding, Code Debugging, Context Help, Creating Sub-VIs Boolean, Mechanical action- switch, and latch actions, String data types, enum, ring, Dynamics.	**06 Hrs**
UNIT-II	
Fundamentals of Virtual Instrumentation Programming: For Loop, While Loop, shift registers, stack shift register, feedback node, and tunnel. **Timing function**: Timing VI, elapsed time, wait function. Case structures, formula node, Sequence structures, Arrays and clusters, visual display types- graphs, charts, XY graph. Local and Global variables.	**09 Hrs**
UNIT-III	
Error Handling- error and warning, default error node, error node cluster, automatic and manual error handling. **String Handling:** Introduction, String Functions, LabVIEW String Formats. **File Input/ Output:** Introduction, File Formats, File I/O Functions and file Path functions. **Design patterns:** Producer/consumer, event handler, derived design pattern, Queued message handler, Producer/consumer (events), Producer/consumer (state machine).	**08 Hrs**
UNIT-IV	
Data Acquisition: Introduction to data acquisition, Analog Interfacing Connecting signal to board, Analog Input/output techniques digital I/O, counters, NI-DAQmx tasks. **DAQ Hardware configuration:** Introduction, Measurement and Automation Explorer, DAQ Assistants, Analysis Assistants. **Interfacing Instruments: GPIB and RS232:** Introduction, RS232 Vs. GPIB, Handshaking, GPIB Interfacing, RS232C/RS485 Interfacing, and VISA.	**06 Hrs**
UNIT-V	
Advanced Topics In LabVIEW: Use of analysis tools and application of VI: Fourier transforms Power spectrum, Correlation methods, windowing & filtering.	**06 Hrs**

Inter-Process Communication, Notifier, Semaphore, Data Sockets. **Simulation of systems using VI:** Development of Control system, Image acquisition and processing.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember and Understand the fundamentals of Virtual Instrumentation and data Acquisition.
CO2:	Apply the theoretical concepts to realize practical systems.
CO3:	Analyze and evaluate the performance of Virtual Instrumentation Systems.
CO4:	Create a VI system to solve real time problems using data acquisition.

Reference Books	
1	Virtual instrumentation Using LabVIEW, Jovitha Jerome, 4th Edition, 2010, PHI Learning Pvt. Ltd., ISBN: 978-812034035.
2	Virtual Instrumentation Using LabVIEW, Sanjay Gupta & Joseph John, 2nd Edition, New Delhi, 2010,Tata McGraw Hill Publisher Ltd., ISBN: 978-0070700284
3	LabVIEW for Everyone: Graphical Programming made easy and fun,Jeffrey Travis, Jim Kring, 3rd Edition, 2006, Prentice Hall,ISBN: 978-0131856721.
4	Data Acquisition using LabVIEW,Behzad Ehsani, 1st Edition,2017, Packt Publishing, ISBN: 978-1782172161.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marksis executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO MAPPING												
CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
CO1	**2**	**1**	**1**	**1**	**2**	**-**	**-**	**-**	**2**	**2**	**-**	**1**
CO2	**1**	**1**	**1**	**1**	**2**	**-**	**-**	**-**	**2**	**2**	**-**	**1**
CO3	**1**	**-**	**1**	**1**	**2**	**-**	**-**	**-**	**2**	**2**	**-**	**1**
CO4	**2**	**1**	**1**	**2**	**3**	**-**	**-**	**-**	**2**	**2**	**-**	**2**

Low-1 Medium-2 High-3

Semester: VI		
INTRODUCTION TO MOBILE APPLICATION DEVELOPMENT (Group E: Global Elective)		
Course Code: 16G6E09		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours : 36L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	Learn Android application development platform for mobile devices and use it.
2	Understand mobile application architecture and its components.
3	Define Android specific programming concepts such as activities, intents, fragments, services, broadcast receivers and content providers.
4	Describe sensors like motion sensors, environmental sensors, and positional sensors; most commonly embedded in Android devices along with their application programming interface.

UNIT I	
Overview of Software platforms and Development: Mobile OS: Android development platform and tools, Programming language, Emulator, SDK and Development Environments **Creating Applications and Activities:** Introducing the Application Manifest File; Creating Applications and Activities; Architecture Patterns (MVC); Android Application Lifecycle.	**07 Hrs**
UNIT II	
User Interface Design: Fundamental Android UI Design; Introducing Layouts; Introducing Fragments. **Intents and Broadcasts**: Introducing Intents; Creating Intent Filters and Broadcast Receivers.	**07 Hrs**
UNIT III	
Database and Content Providers: Introducing Android Databases; Introducing SQLite; Content Values and Cursors; Working with SQLite Databases; Creating Content Providers; Using Content Providers; Case Study: Native Android Content Providers.	**07 Hrs**
UNIT IV	
Location Based Services, Telephony and SMS: Using Location-Based Services; Using the Emulator with Location-Based Services; Selecting a Location Provider; Using Proximity Alerts; Using the Geocoder; Example: Map-based activity; Hardware Support for Telephony; Using Telephony; Introducing SMS and MMS.	**08 Hrs**
UNIT V	
Hardware Support and Devices (AUDIO, VIDEO, AND USING THE CAMERA): Using Sensors and the Sensor Manager; Monitoring a Device's Movement and Orientation; Introducing the Environmental Sensors; Playing Audio and Video; Using Audio Effects; Using the Camera; Recording Video	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Assess the basic framework and usage of SDK to build GUI and apply advanced technologies in developing Android mobile applications.
CO2:	Differentiate techniques for persisting user data, such as shared preferences, traditional file systems (internal and external storage), and SQLite database
CO3:	Articulate the communication programming features and capabilities of Android platforms.
CO4:	Design and create innovative, sophisticated mobile applications using Android platform.

Reference Books	
1.	Professional Android 4 Application Development, Reto Meier, WROX Press, 2012, Wiley Publishing, ISBN: 9781118102275
2.	Android Application Development: Programming with the Google SDK, John Lombardo, Blake Meike, Rick Rogers and Zigurd Mednieks, 2009, O'Reilly Media, Inc. ISBN: 9788184047332
3.	Hello Android, Introducing Google's Mobile Development Platform, Ed Burnette, 3rd Edition, Pragmatic Programmers, LLC.ISBN: 9781934356562
4.	Android Studio Development Essentials - Android 6, Neil Smyth, 2015, Createspace Independent Publishing Platform, ISBN: 9781519722089

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
CO1	2	3	-	-	3	-	-	-	-	-	-	2
CO2	3	3	3	-	3	1	-	-	-	2	-	2
CO3	-	3	3	-	3	2	-	-	-	2	1	3
CO4	3	3	3	2	3	2	2	2	2	2	1	3

Low-1 Medium-2 High-3

Semester: VI		
AUTOMOTIVE ENGINEERING (Group E: Global Elective)		
Course Code:	**16G6E10**	**CIE Marks: 100**
Credits: L:T:P:S	**3:0:0:0**	**SEE Marks: 100**
Hours:	**36L**	**SEE Duration: 3Hrs**
Course Learning Objectives: The students will be able to		
1	Identify the different sub-systems in automobiles.	
2	Describe the functions of each of the sub-systems and its effect.	
3	Discuss fuel injection, transmission, braking, steering, suspension, air intake and exhaust systems.	
4	Explain the importance of selection of suitable sub-system for a given performance requirement.	

UNIT-I	
Automobile Engines Classifications of Internal Combustion Engines based on no. of cylinders, Arrangement of cylinders, Type of fuel and no. of strokes**.** Engine construction and nomenclature. Thermodynamic principles of Otto and Diesel cycle. Operation in a 4 stroke engine. Direct and indirect injection. Combustion stages in engines. Fuels: Gasoline, Diesel, LPG and Natural Gas For automotive applications. Fuel properties- Octane number and Cetane number. Pollutants and Emission norms- Regulated pollutants and its effects, Regulations as per emission norms.	**06 Hrs**
UNIT-II	
Engine Auxiliary Systems: AirIntake and Exhaust System- Working principle ofAir filters, Intake manifold, Turbocharger, Intercooler, Exhaust manifold, Catalytic convertor, Exhaust Gas Recirculation system, Muffler. Cooling system- Components, working principle, Coolant. Lubrication system- Components, Properties of lubricating oil, Viscosity numbers. Fuel system- Working principle of Fuel Injection Pump, Injector, Nozzle, Fuel filter. Working of ignition system, Battery, Immobilizer.	**08 Hrs**
UNIT-III	
Transmission: Clutch- Classification and working, Gear box- Classification, Working of sliding mesh and Synchromesh transmission, Automatic transmission. Propeller shaft, Differential assembly and rear axle- Working. Wheels and Tyres- Wheel alignment and balancing classification of tyres, Radial, Tubeless.	**08 Hrs**
UNIT-IV	
Vehicular Auxiliary Systems: Suspension- Front and rear suspension working, Types of springs. Brake- Classification and Components - Disc and drum brakes, Hydraulic, parking brake, Front and rear wheel brakes. Antilock Braking Systems. Steering- components and operation of power steering. Vehicle frame and body classification- Hatchback, Sedan, SUV. Safety systems- Passive safety systems, Active safety systems- Principle of Electronic Stability Program, Air bags, Crash testing methods.	**06 Hrs**
UNIT-V	
Demonstrations of Automobile Systems: Engine performance measurement in terms of Brake power, Emission measurement and principle, Drawing Valve Timing Diagram for multi-cylinder engine, Production and properties of biodiesel.	**06 Hrs**

Course Outcomes: After completing the course, the students will be able to	
1	Describe the different types of automotive systems. (L1- L2)
2	Construct the Valve Timing Diagram for multi-cylinder engines. (L3)
3	Detect the automotive exhaust pollutants using gas analyzer. (L4)
4	Evaluate the performance of engines by determining Brake Power. (L6)

Reference Books	
1.	Automotive Engineering Fundamentals, Richard Stone and Jeffrey K. Ball, 2004 , SAE International , ISBN: 0768009871
2.	Bosch Automotive Handbook, Robert Bosch, 9th Edition, 2004, ISBN: 9780768081527.
3.	Automotive Engineering e-Mega Reference, David Crolla, Butterworth-Heinemann, 1st Edition , 2009 , ISBN: 9781856175784.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**1**	**1**		**1**			**2**		**2**			**1**
CO2		**2**										
CO3		**2**	**1**			**2**		**1**			**2**	**1**
CO4	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**2**	**2**	

Low-1 Medium-2 High-3

Semester: VI		
MOBILE NETWORK SYSTEMS AND STANDARDS (GROUP E: GLOBAL ELECTIVE)		
Course Code: 16G6E11		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 34L		**SEE Duration: 03Hrs**

Course Learning Objectives: The students will be able to	
1	Understand land mobile concepts, radio link design and cellular network.
2	Compare the standards of WPAN, WLAN and WMAN.
3	Analyze WPAN, WLAN and WMAN standards and their architecture.
4	Design and demonstrate wireless networks for various applications.

UNIT-I	
Cellular Wireless Networks: Principles of cellular Networks, cellular system components and Operations, channel assignment, Attributes of CDMA in cellular system.	**06 Hrs**
UNIT-II	
Second generation Cellular Networks: GSM architecture, IS-95, GPRS, EDGE.	**08 Hrs**
UNIT-III	
Third generation cellular systems: WCDMA, IMT 2000 and LTE, Convergence in the network.	**06 Hrs**
UNIT-IV	
Wireless Personal Area Networks: Network architecture, components, Applications, Zigbee, Bluetooth. **Wireless Local Area networks:** Network Architecture, Standards, Applications.	**08 Hrs**
UNIT-V	
Wireless Metropolitan Area Networks: IEEE 802.16 standards, advantages, WMAN Network architecture, Protocols, Applications.	**06 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the architectures and characteristics of different mobile networks. (L1- L2)
CO2	Apply the Network standards to a suitable application (L3)
CO3	Analyze the operation of various network technologies and standards (L4)
CO4	Evaluate the performance of various network technologies (L5)

Reference Books	
1	Wireless Communication, Upena Dalal, 1st Edition , 2009, Oxford higher Education, ISBN-13:978-0-19-806066-6.
2	Wireless and Mobile Networks Concepts and Protocols, Dr. sunil Kumar s Manvi, 2010, Willey India Pvt. Ltd., ISBN: 978-81-265-2069-5.
3	Wireless Communications Principles and practice, Theodore S Rappaport, 2nd Edition, Pearson, ISBN 97881-317-3186-4.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of Quizzes (Q), Tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	---	2	---	---	2	---	2	---	1
CO2	3	3	2	---	2	---	---	2	---	2	---	1
CO3	3	3	3	---	2	---	---	2	---	2	---	2
CO4	3	3	3	---	3	---	---	2	---	2	---	2

Low-1 Medium-2 High-3

Semester: VI		
APPLIED PARTIAL DIFFERENTIAL EQUATIONS (Group E: Global Elective)		
Course Code:16G6E12		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 35L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Adequate exposure to learn basics of partial differential equations and analyze mathematical problems to determine the suitable analytical technique.
2	Use analytical techniques and finite element technique for the solution of elliptic, parabolic and hyperbolic differential equations.
3	Solve initial value and boundary value problems which have great significance in engineering practice using partial differential equations.
4	Identify and explain the basics of partial differential equations and use the same to analyze the behavior of the system.

Unit-I	
Partial Differential Equations of first order: Introduction to formation of partial differential equations, Cauchy problem, Orthogonal surfaces, First order non-linear partial differential equations-Charpit's method, Classification and canonical forms of partial differential equations.	**07 Hrs**
Unit – II	
Elliptic Differential Equations: Derivation of Laplace and Poisson equation, Separation of variable method, Dirichlet problem, Neumann problem, Solution of Laplace equation in cylindrical and spherical coordinates.	**07 Hrs**
Unit -III	
Parabolic Differential Equations: Formation and solution of Diffusion equation, Dirac-Delta function, Separation of variable method, Solution of Diffusion equation in cylindrical and spherical coordinates.	**07Hrs**
Unit –IV	
Hyperbolic Differential Equations: Formation and solution of one dimensional wave equation, D'Alembert's solution, vibrating string, Forced vibration, Periodic solution of one dimensional wave equation in cylindrical and spherical coordinates, Vibration of Circular membrane.	**07Hrs**
Unit –V	
Numerical solutions of Partial Differential Equations: Finite difference method for Elliptic, Parabolic and Hyperbolic partial differential equations, Introduction to the finite element method-simple problems.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Identify and interpret the fundamental concepts of formation and solution of parabolic, hyperbolic and elliptic differential equations using analytical and numerical methods.
CO2:	Apply the knowledge and skills of analytical and numerical methods to solve the parabolic, hyperbolic and elliptic differential equations arising in the field of science and engineering.

CO3:	Analyze the physical problem to establish mathematical model and use appropriate method to solve and optimize the solution using the appropriate governing equations.
CO4:	Distinguish the overall mathematical knowledge to demonstrate and analyze the solution of parabolic, hyperbolic and elliptic differential equations arising in practical situations.

Reference Books	
1	Partial Differential Equations, K. Sankara Rao, Prentice-hall of India, 3rd Edition, 2012, ISBN: 978-81-203-3217-1.
2	Advanced Engineering Mathematics, Erwin Kreyszig, Wiley, 10th Edition, 2016, ISBN: 978-81-265-5423-2.
3	Numerical methods for scientific and engineering computation, M K Jain, S. R. K. Iyengar, R. K. Jain, New Age International Publishers, 6th Edition, 2012, ISBN-13: 978-81-224-2001-2.
4	An Introduction to the finite element method, J. N. Reddy, McGraw Hill, 3rd Edition, 2005, ISBN 13: 9780072466850.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO2	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO3	**2**	**3**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
CO4	**3**	**3**	**1**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**3**

High-3: Medium-2: Low-1

Semester: VI		
AIRCRAFT SYSTEMS **(Group E: Global Elective)**		
Course Code: 16GE6B13		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives: To enable the students to:	
1	List the various systems involved in the design of an aircraft
2	Demonstrate the technical attributes of all the subsystems of an aircraft
3	Explain the significance of each systems and its subsystems for developing an airplane
4	Demonstrate the integration of the systems with the airplane

Unit-I	
Flight Control Systems : Primary and secondary flight controls, Flight control linkage system, Conventional Systems, Power assisted and fully powered flight controls.	**07 Hrs**
Unit – II	
Aircraft Hydraulic & Pneumatic Systems : Components of a typical Hydraulic system, Working or hydraulic system, Power packs, Hydraulic actuators. Pneumatic system and components, Use of bleed air, Landing gear and braking, Shock absorbers-Retraction mechanism.	**08 Hrs**
Unit -III	
Aircraft Fuel Systems : Characteristics of aircraft fuel system, Fuel system and its components, Gravity feed and pressure feed fuel systems, Fuel pumps-classification, Fuel control unit.	**07 Hrs**

Unit -IV	
Environmental Control Systems : Air-conditioning system, vapour cycle system, de-icing and anti-icing system, Fire detection- warning and suppression. Crew escape aids. **Engine Systems :** Engine starting sequence, Starting and Ignition systems, Engine oils and a typical lubricating system.	**07 Hrs**
Unit -V	
Aircraft Instruments : Instruments displays, panels & layouts, Instrumentation grouping, Navigation instruments, Radio instruments, Hydraulic and Engine instruments. **Air Data Instruments :** Basic air data system and probes, Mach meter, Air speed indicator, Vertical speed indicator, Barometric pressure sensing, Altimeter, Air data alerting system- angle of attack sensing, stall warning, Mach warning, altitude alerting system.	**07 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Categorise the various systems required for designing a complete airplane
2	Comprehend the complexities involved during development of flight vehicles.
3	Explain the role and importance of each systems for designing a safe and efficient flight vehicle
4	Demonstrate the different integration techniques involved in the design of an air vehicle

Reference Books	
1	John D. Anderson, Introduction to Flight, 7th Edition, 2011, McGraw-Hill Education, ISBN 9780071086059.
2	Moir, I. and Seabridge, A.,Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, 3rd Edition, 2008, Wiley Publications, ISBN- 978-0470059968

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**1**
CO3	**2**	**2**	**3**	**3**	**1**							**2**
CO4	**3**	**3**	**3**	**3**	**1**	**2**	**1**	**2**				**1**

High-3 : Medium-2 : Low-1

VI Semester		
PROFESSIONAL PRACTICE – III **EMPLOYABILITY SKILLS AND PROFESSIONAL DEVELOPMENT OF ENGINEERS**		
Course Code: 16HS68		**CIE Marks:** 50
Credits: L:T:P:S: 0:0:1:0		**SEE Marks:** NA
Hours: 18 Hrs		**CIE Duration:** 02 Hrs

Course Learning Objectives: The students will be able to	
1	Improve qualitative and quantitative problem solving skills.
2	Apply critical and logical thinking process to specific problems.
3	Ability to verbally compare and contrast words and arrive at relationships between concepts, based on verbal reasoning.
4	Applying good mind maps that help in communicating ideas as well as in technical documentation

V Semester	
UNIT-I	
Aptitude Test Preparation- Importance of Aptitude tests, Key Components, Quantitative Aptitude – Problem Solving, Data Sufficiency, Data Analysis - Number Systems, Math Vocabulary, fraction decimals, digit places etc. Reasoning and Logical Aptitude, - Introduction to puzzle and games organizing information, parts of an argument, common flaws, arguments and assumptions. Analytical Reasoning, Critical Reasoning.	**06 Hrs**
UNIT-II	
Verbal Analogies - What are Analogies, How to Solve Verbal Analogies & developing Higher Vocabulary, Grammar, Comprehension and Application, Written Ability. Non- Verbal Reasoning, Brain Teasers. Creativity Aptitude. Group Discussion- Theory &Evaluation : Understanding why and how is the group discussion conducted, The techniques of group discussion, Discuss the FAQs of group discussion, body language during GD.	**06 Hrs**
UNIT-III.A	
Resume Writing- Writing Resume, how to write effective resume, Understanding the basic essentials for a resume, Resume writing tips Guidelines for better presentation of facts.	**06 Hrs**
VI Semester	
UNIT-III.B	
Technical Documentation - Introduction to technical writing- Emphasis on language difference between general and technical writing, Contents in a technical document, Report design overview & format Headings, list & special notes, Writing processes, Translating technical information, Power revision techniques, Patterns & elements of sentences, Common grammar, usage & punctuation problems.	**06 Hrs**
UNIT-IV	
Interview Skills -a) Personal Interviews , b) Group Interviews , c) Mock Interviews - Questions asked & how to handle them, Body language in interview, Etiquette, Dress code in interview, Behavioral and technical interviews, Mock interviews - Mock interviews with different Panels. Practice on stress interviews, technical interviews, General HR interviews etc.	**06 Hrs**
UNIT-V	
Interpersonal Relations - Optimal Co-existence, Cultural Sensitivity, Gender	**06 Hrs**

sensitivity, Adapting to the Corporate Culture- Capability & Maturity Model, Decision Making Analysis, Brain Storm. Adapting to the Corporate Culture.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Inculcate employability skill to suit the industry requirement.
CO2:	Analyze problems using quantitative and reasoning skills
CO3:	Exhibit verbal aptitude skills with appropriate comprehension and application.
CO4:	Focus on Personal Strengths and Competent to face interviews and answer
Reference Books	
1.	The 7 Habits of Highly Effective People, Stephen R Covey Free Press, 2004 Edition, ISBN: 0743272455
2.	How to win friends and influence people, Dale Carnegie General Press, 1st Edition, 2016, ISBN: 9789380914787
3.	Crucial Conversation: Tools for Talking When Stakes are High, Kerry Patterson, Joseph Grenny, Ron Mcmillan 2012 Edition, McGraw-Hill Publication ISBN: 9780071772204
4.	Aptimithra: Best Aptitude Book ,Ethnus,2014 Edition, Tata McGraw Hill ISBN: 9781259058738

Scheme of Continuous Internal Examination (CIE)
Evaluation of CIE will be carried out in TWO Phases.

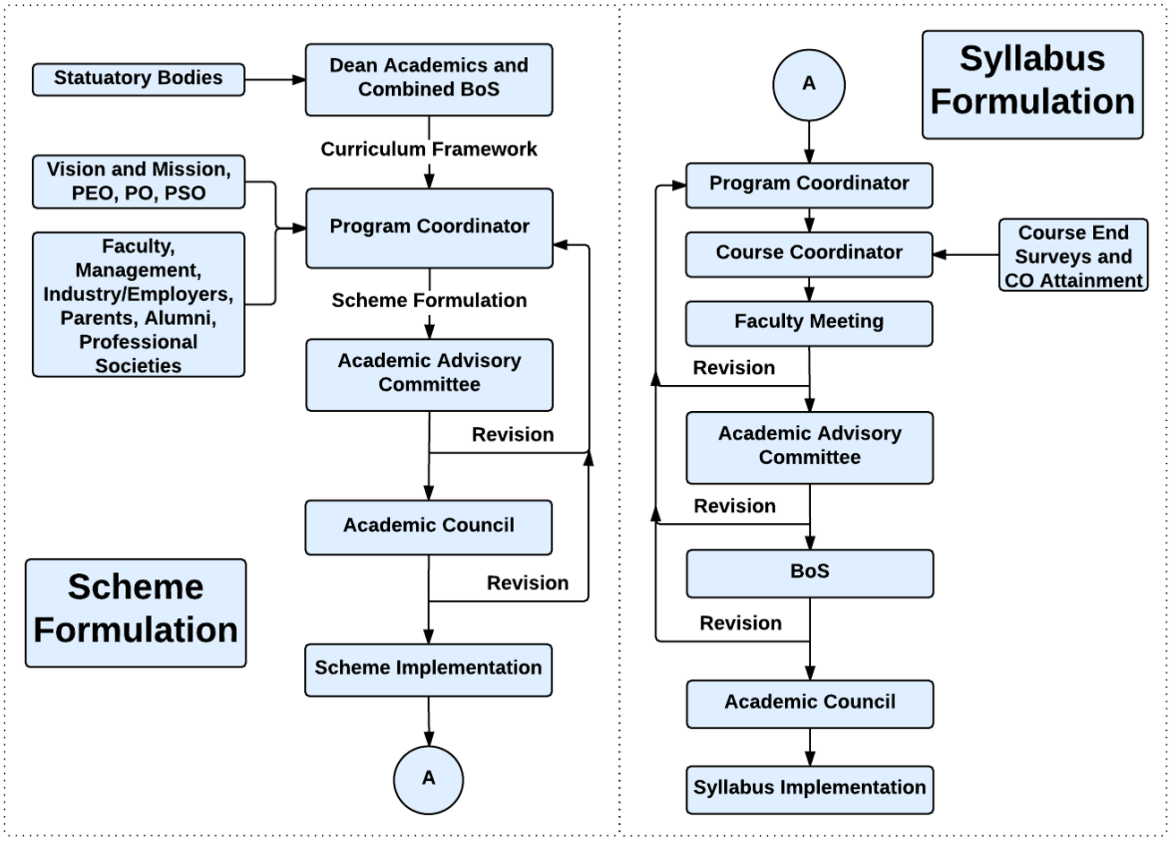
Phase	Activity	Weightage
I	Test 1 is conducted in V Sem for 50 marks (15 Marks Quiz and 35 Marks Descriptive answers) after completion of Unit-1, Unit-2 and Unit -3.A for 18 hours of training sessions.	50%
II	Test 2 is conducted in VI Sem for 50 marks ((15 Marks Quiz and 35 Marks Descriptive answers) after completion of Unit -3B, Unit - 4 and Unit-5 for 18 hours of training sessions.	50%
	At the end of the VI sem Marks of Test 1 and Test 2 is consolidated for 50 marks (Average of Test1 and Test 2 (T1+T2/2). The grading is provided by the Coe. The final CIE marks is scrutinized by the committee comprising of HSS- Chairman, Training Co-ordinator, respective department Staff Placement co-ordinator before submitting to CoE.	

SEE: NA

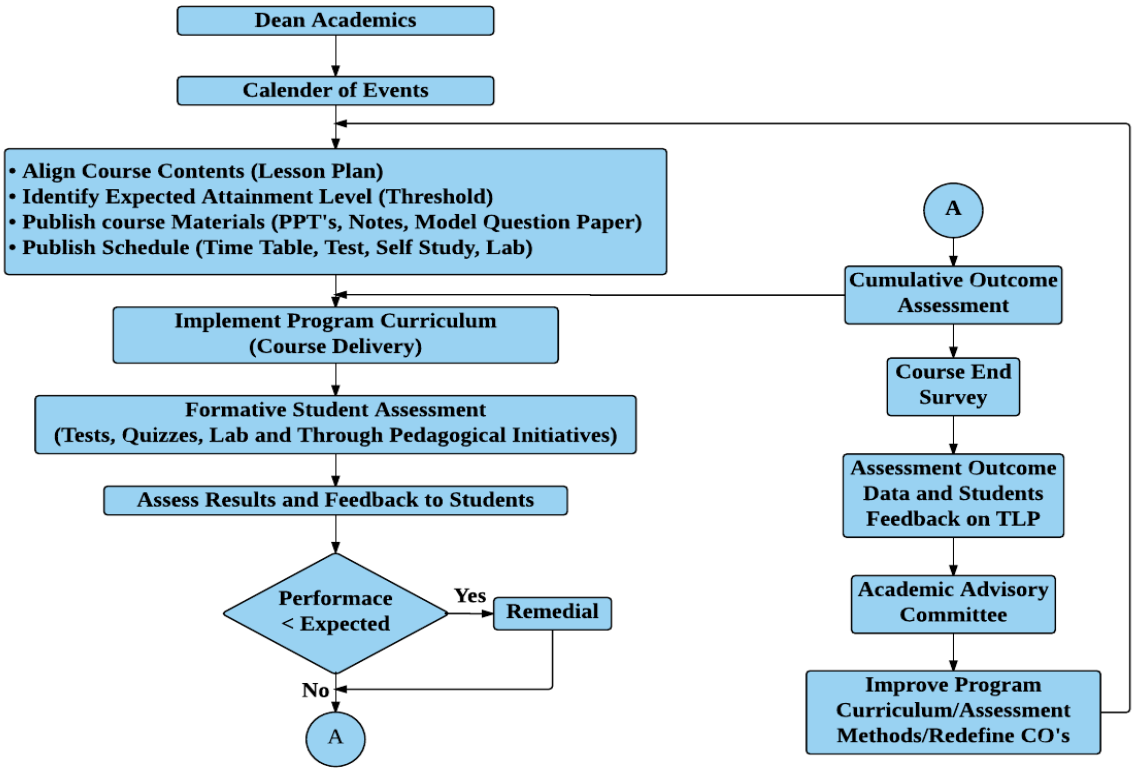
CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	---	___	---	----	1	----	1	1	1	2	1
CO2	1	2	2	---	---	---	----	1	2	1	2	1
CO3	---	---	3	---	---	1	---	2	1	2	1	---
CO4	---	---	___	---	----	1	3	1	1	1	1	---

Low-1 Medium-2 High-3

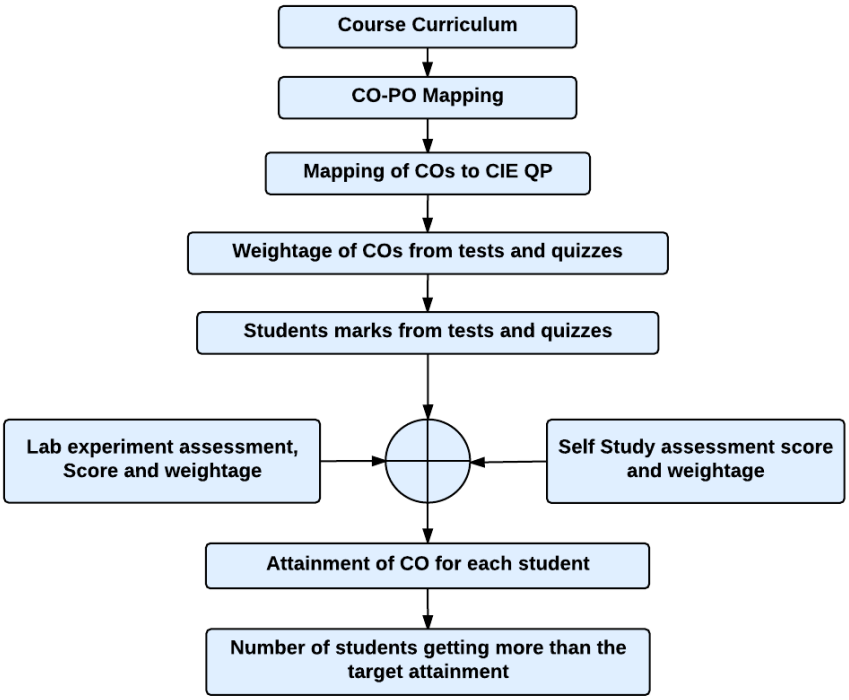
Curriculum Design Process



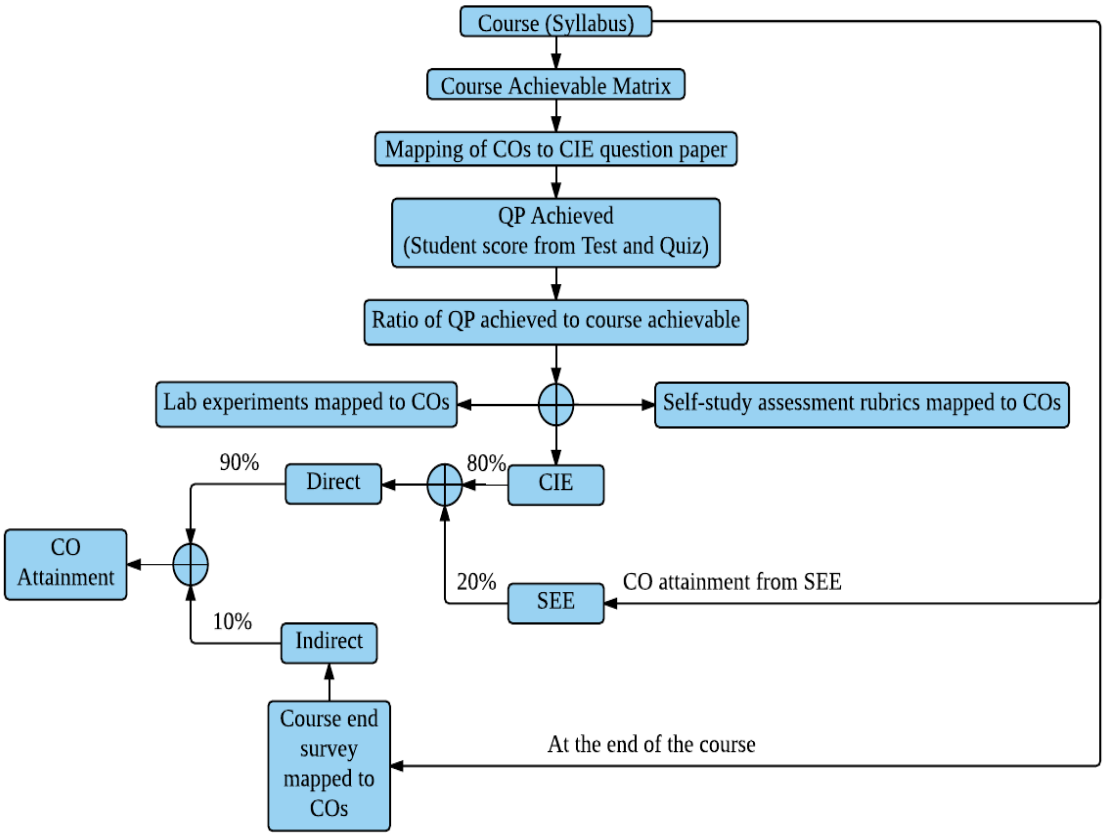
Academic Planning and Implementation


Dean Academics
Calender of Events
• Align Course Contents (Lesson Plan)
• Identify Expected Attainment Level (Threshold)
• Publish course Materials (PPT's, Notes, Model Question Paper)
• Publish Schedule (Time Table, Test, Self Study, Lab)
Implement Program Curriculum (Course Delivery)
Formative Student Assessment (Tests, Quizzes, Lab and Through Pedagogical Initiatives)
Assess Results and Feedback to Students
Performace < Expected
Yes
Remedial
No
A
A
Cumulative Outcome Assessment
Course End Survey
Assessment Outcome Data and Students Feedback on TLP
Academic Advisory Committee
Improve Program Curriculum/Assessment Methods/Redefine CO's

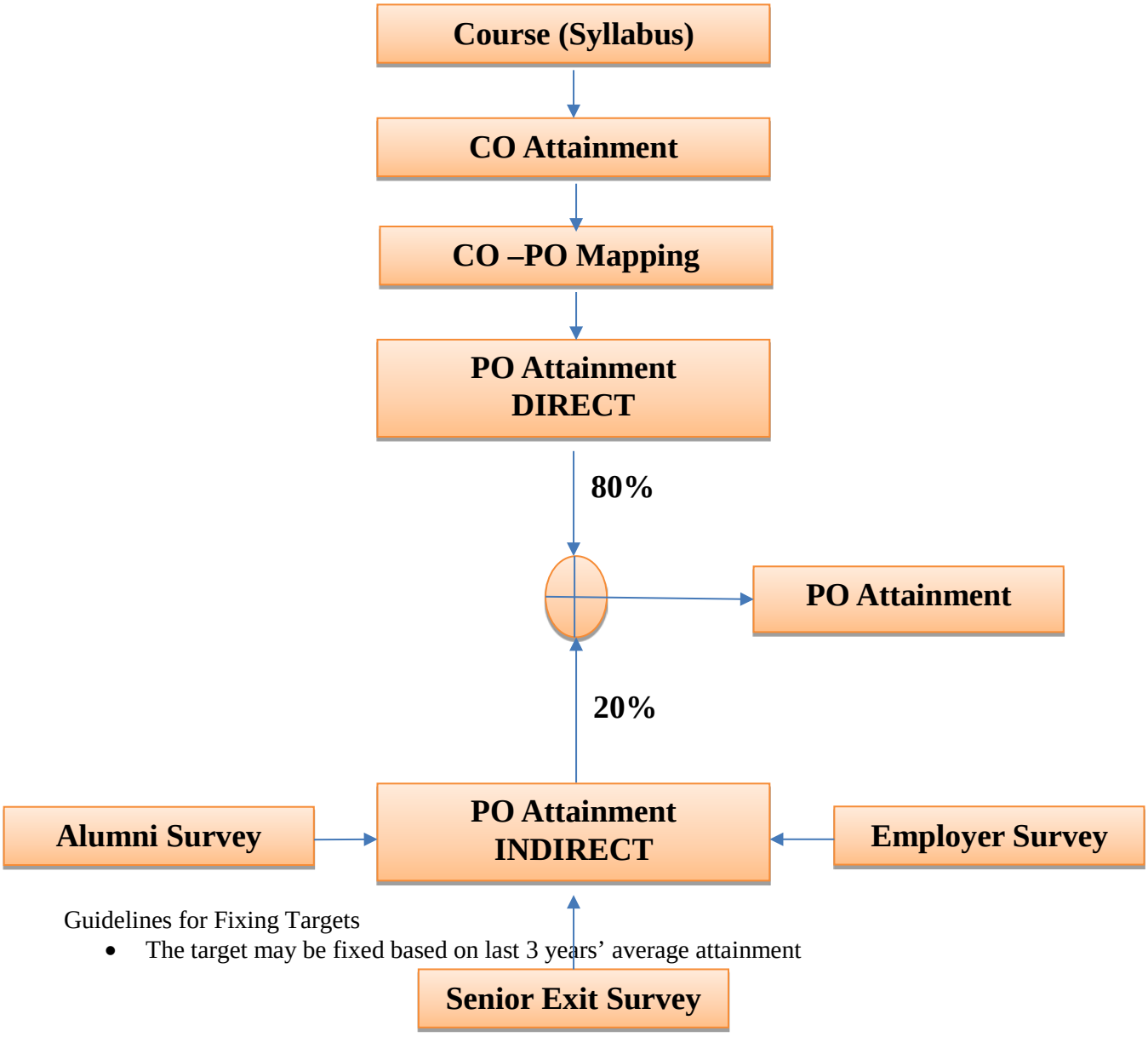
PROCESS FOR COURSE OUTCOME ATTAINMENT



Final CO Attainment Process



Program Outcome Attainment Process



Guidelines for Fixing Targets

- The target may be fixed based on last 3 years' average attainment

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 t h e 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 t h e 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.