R.V.COLLEGE OF ENGINEERING

(Autonomous Institution Affiliated to VTU, Belagavi)

R.V. Vidyaniketan Post, Mysore Road

Bengaluru – 560 059

Scheme and Syllabus of I& II Semesters

(Autonomous System of 2018 Scheme)

Master of Technology (M.Tech)

in

BIOTECHNOLOGY

DEPARTMENT OF

BIOTECHNOLOGY

INNER FRONT COVER PAGE

College Vision & Mission
(To be included from our side)

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Department Vision & Mission

VISION

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

MISSION

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

ABBREVIATIONS

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

INDEX

IISemester			
Sl. No.	**Course Code**	**Course Title**	**Page No.**
1.	18MBT21	Upstream Process Technology	
2.	18MBT22	Pharmaceutical Technology	
3.	18IEM23	Research Methodology	
4.	18MBT24	Minor Project	
GROUP C: CORE ELECTIVES			
1.	18MBT2C1	Biomedical Instrumentation and Digital health	
2.	18MBT2C2	Crop improvement and molecular breeding	
3.	18MBT2C3	Insilico drug design	
4.			
GROUP D: CORE ELECTIVES			
1.	18MBT2D1	Medical Implant and Devices	
2.	18MBT2D2	Food Technology	
3.	18MBT2D3	High Performance Computing	
4.			
GROUP G: GLOBAL ELECTIVES			
1.	18CS2G01	Business Analytics	
2.	18CV2G02	Industrial & Occupational Health and Safety	
3.	18IM2G03	Modeling using Linear Programming	
4.	18IM2G04	Project Management	
5.	18CH2G05	Energy Management	
6.	18ME2G06	Industry 4.0	
7.	18ME2G07	Advanced Materials	
8.	18CHY2G08	Composite Materials Science and Engineering	
9.	18PHY2G09	Physics of Materials	
10.	18MAT2G10	Advanced Statistical Methods	

R V COLLEGE OF ENGINEERNG, BENGALURU-560 059
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DEPARTMENT OF BIOTECHNOLOGY
M.Tech in BIOTECHNOLOGY

FIRST SEMESTER CREDIT SCHEME

Sl. No.	Course Code	Course Title	BoS	Credit Allocation			
				L	T	P	Total Credits
1	18MAT11A	Applied Mathematics	Math	4	0	0	4
2	18MBT12	Molecular Biology and Genetic Engineering	BT	4	0	1	5
3	18MBT13	Computational Genomics and Proteomics	BT	4	0	1	5
4	18MBT1AX	Group A: Core Elective	BT	3	1	0	4
5	18MBT1BX	Group B: Core Elective	BT	3	1	0	4
6	18HSS14	Professional Skills Development * CIE will be conducted, Students have to pass CIE	HSS	0	0	0	0
Total number of Credits				18	2	2	**22**
Total Number of Hours / Week							

SECOND SEMESTER CREDIT SCHEME

Sl. No.	Course Code	Course Title	BoS	Credit Allocation			
				L	T	P	Total Credits
1	18MBT21	Upstream Process Technology	BT	4	0	1	5
2	18MBT22	Pharmaceutical Technology	BT	4	0	0	4
3	18IEM23	Research Methodology	IEM	3	0	0	3
4	18MBT2CX	Group -C	BT	3	1	0	4
5	18MBT2DX	Group -D	BT	3	1	0	4
6	18XX2GXX	Global Elective	BT	3	0	0	3
7	18MBT24	Minor Project	BT	0	0	2	2
Total number of Credits				**20**	**2**	**3**	**25**
Total Number of Hours / Week							

I Semester		
GROUP A: CORE ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	18MBT1A1	Stem cells and Tissue Engineering
2.	18MBT1A2	Agricultural Biotechnology and Sustainability
3.	18MBT1A3	Shell Scripting
4.		
GROUP B: CORE ELECTIVES		
1.	18MBT1B1	Human diseases
2.	18MBT1B2	Alternative farming
3.	18MBT1B3	System Biology
4.		
II Semester		
GROUP C: CORE ELECTIVES		
1.	18MBT2C1	Biomedical Instrumentation and Digital health
2.	18MBT2C2	Crop improvement and molecular breeding
3.	18MBT2C3	Insilico drug design
4.		
GROUP D: CORE ELECTIVES		
1.	18MBT2D1	Medical Implant and Devices
2.	18MBT2D2	Food Technology
3.	18MBT2D3	High Performance Computing
4.		

GROUP E: GLOBAL ELECTIVES				
Sl. No.	**Host Dept**	**Course Code**	**Course Title**	**Credits**
1.	CS	18CS2G01	Business Analytics	3
2.	CV	18CV2G02	Industrial & Occupational Health and Safety	3
3.	IM	18IM2G03	Modelling using Linear Programming	3
4.	IM	18IM2G04	Project Management	3
5.	CH	18CH2G05	Energy Management	3
6.	ME	18ME2G06	Industry 4.0	3
7.	ME	18ME2G07	Advanced Materials	3
8.	CHY	18CHY2G08	Composite Materials Science and Engineering	3
9.	PHY	18PHY2G09	Physics of Materials	3
10.	MAT	18MAT2G10	Advanced Statistical Methods	3

Semester:I		
APPLIED MATHEMATICS		
CourseCode:18MAT11A		**CIE Marks:100**
Credits: L:T:P: 4:0:0		**SEE Marks:100**
Hours: : 48L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Adequate exposure to learn statistical techniques, random phenomena for analyzing data to find the suitable mathematical/probability models for solving practical situation in engineering applications.
2	To learn fundamentals of linear algebra, solution of system of linear equations and eigen value problems used in various fields of engineering and science.
3	Explore the possibility of finding approximate solutions using numerical methods in the absence of analytical solutions of various systems.
4	Apply the concepts of optimization to solve engineering applications of optimization which have great importance in the field of engineering.

Unit-I	
Statistics: Method of least squares, fitting of straight line, linearization of nonlinear laws, curve fitting by polynomials, correlation, coefficient of correlation, lines of regression, Spearman rank correlation.	09 Hrs
Unit –II	
Probability Distributions: Introduction to probability, Random Variables-Discrete and continuous random variables, important measures and moment generating functions, standard distributions-Binomial, Exponential, Normal and Gamma distributions.	**09 Hrs**
Unit –III	
System of Linear Equations and Eigen Value Problems: System of linear equations -LU decomposition and Gauss-Jordan method, Eigen value problems – Bounds on eigen values, Eigen values and Eigen vectors of real symmetric matrices -Jacobi method, Power method and Inverse Power method.	**10 Hrs**
Unit –IV	
Numerical Solution of Differential Equations: Boundary value problems (BVP's)–Finite difference method for linear and nonlinear problems, Shooting method and Galerkin method. Finite differences-Implicit and Explicit scheme, Finite difference methods for parabolic, Elliptic and Hyperbolic PDE, Finite element method and simple problems	**10 Hrs**
Unit –V	
Engineering Optimization: Engineering applications of optimization, statement of an optimization problem-design vector, design constraints, constraint surface, objective function and objective function surface. Multivariable optimization with inequality constraints-Kuhn-Tucker conditions, Constraint qualification, Genetic operators, Neural-Network-based Optimization. Optimization of Fuzzy systems.	**10 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Identify and interpret the fundamental concepts of statistics, distributions, linear algebra, differential equations and optimization arising in various fields engineering.
CO2:	Apply the knowledge and skills of statistical/numerical/optimization techniques to solve problems of least squares, probability distributions, linear equations, eigen value problems and differential equations which have great importance in science and engineering.
CO3:	Analyze the physical problem to establish statistical/mathematical model and use appropriate method to solve and optimize the solution.
CO4:	Distinguish the overall mathematical knowledge gained to demonstrate and analyze the problems of method of least squares, probability distributions, linear equations, eigen value problems, differential equationsand optimizationarising in practical situations.

Reference Books:	
1	Theory and Problems of probability, Schaum's Outline Series, Seymour Lipschutz and Marc lars Lipson, 2nd edition, ISBN: 0-07-118356-6.
2	Introductory method of numerical analysis, S. S. Sastry, Prentice-Hall India Pvt. Ltd., 4th edition, 2009, ISBN : 81-203-1266-X.
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	Engineering Optimization Theory and Practice, Singiresu S. Rao, 3rd edition, New Age International (P)Ltd., ISBN: 81-224-1149-5.

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

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: I		
MOLECULAR BIOLOGY AND GENETIC ENGINEERING (Theory and Practice)		
Course Code: 18 MBT 12		**CIE Marks:100+50**
Credits: L:T:P: 4:0:1		**SEE Marks:100+50**
Hours: : 44L+25P		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Acquire knowledge of central dogma of molecular biology, rDNA technology and Immunotechnology.
2	Study of the techniques of Recombinant DNA technology and Immunotechnology.
3	Acquire the various methods of genetic transformation of living systems, and selection, screening and analysis of recombinants.
4	Know various advanced techniques of immunotechnology, and genetic manipulation of microbes, plants and animals.

Unit-I	
Replication, Transcription and Translation: Molecular structure of genes and chromosomes, Replication: Mechanism of Initiation, elongation and termination in prokaryotes and eukaryotes. DNA damage and repair: Photoreactivation, Nucleotide excision repair, Mismatch repair, SOS repair. Recombination: Homologous and non- homologous, site specific recombination. Transcription in prokaryotes and eukaryotes: Mechanism of Initiation, elongation and termination. Promoters and enhancers, Structure and function of different types of RNA and mRNPs. Processing of mRNA, Translation in prokaryotes and eukaryotes: Mechanism of initiation, elongation and termination. Regulation of Translation: Global vs mRNA-specific. Translation inhibitors, Posttranslational modifications of proteins. Protein trafficking and transport.	**09 Hrs**
Unit –II	
Gene regulation: Gene regulation and Operon concept, Constitutive, Inducible and Repressible systems; Operators and Regulatory elements; Positive and negative regulation of operon: lac, trp, ara, his, and gal. RNAi technology: si RNA and miRNA mediated gene silencing, antisense technology. Genome editing: Clustered regularly interspaced short palindromic repeats (CRISPR)/Cas systems, Zinc finger nucleases, Transcription activator-like effector nuclease (TALENS). Mechanism of action of ynthetic Riboswitches,	**09 Hrs**
Unit –III	
Components of rDNA technology: Isolation and purification of DNA (genomic and plasmid) and RNA. Chemical synthesis of DNA: Phosphoramidite method, use of synthesized oligonucleotides. Labelling nucleic acids: Radioactive and non-radioactive, end labeling, nick translation, primer extension. Nucleic acid hybridization, Gel electrophoresis. Restriction enzymes, DNA modifying enzymes (Nucleases, Polymerases), DNA ligases. Host cells: Prokaryotic and eukaryotic hosts. Vectors: plasmid, bacteriophage and other viral vectors, cosmids, Ti plasmid, Ri plasmids, Yeast Episomal Plasmids (YEPs), Yeast integrative plasmids (Yips), Yeast replicative plasmids, Bacmids, Yeast Artificial Chromosome (YAC), mammalian and plant expression vectors, Gate-way vectors.	**09 Hrs**
Unit –IV	
Genetic Transformation, Cloning strategies, Selection, Screening, and analysis of Recombinants: Transformation and transfection, Alternative DNA deliver methods: Electroporation, microinjection, biolistic. Cloning from mRNA: synthesis of cDNA, cloning cDNA in plasmid vectors, cloning cDNA in bacteriophage vectors. Cloning from genomic DNA: Genomic libraries, preparation of DNA fragments for cloning, ligation, packaging, and amplification of libraries. Expression of cloned DNA molecules, Cloning large DNA fragments in BAC and YAC vectors. Genetic selection and screening methods: Using chromogenic substrates, Insertional inactivation, Complementation of defined mutation, other genetic selection methods. Screening using nucleic acid hybridization: Nucleic acid probes, Screening clone banks. Screening using PCR, Immunological screening for expressed genes.	**09 Hrs**

Analysis of cloned genes: Characterization based on mRNA translation in vitro, Restriction mapping, Blotting techniques, DNA sequencing.	
Unit –V	
Immunotechnology: Introduction to Immune System, organs, cells and molecules involved in innate and adaptive immunity. Antibody structure and function, Antigen-antibody interactions, Hybridoma technology for monoclonal antibodies production. Antibody engineering, Detection of molecules using ELISA, RIA, Western blot, immunoprecipitation, flowcytometry, and immunofluorescence microscopy. Insitu localization techniques such as FISH, GISH. Role of monoclonal antibodies in cancer therapy.	**08 Hrs**

Unit-VI (Practical component)	**25 Hrs**
1. Isolation and purification of genomic DNA from prokaryotic/ eukaryotic cells 2. Isolation and purification of plasmid DNA 3. Isolation and purification of total RNA 4. Restriction digestion of DNA 5. Constructing recombinant DNA using gene of interest and vector 6. Preparation of competent cells of *E.coli* and genetic transformation of *E.coli* 7. *Agrobacterium* mediated genetic transformation of plants 8. Amplification of DNA fragments using PCR 9. SDS-PAGE for separation of proteins. 10. Detecting antibodies using enzyme-linked immunosorbent assay (ELISA)	

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explain the mechanism of DNA replication, transcription, translation, gene regulation, recombinant DNA technology and immunotechnology.
CO2:	Apply recombinant DNA technology for genetic manipulation of prokaryotes and eukaryotes.
CO3:	Analyze and evaluate recombinant proteins/compounds, and genetically modified organisms.
CO4:	Design/develop suitable protocol/technique for production of genetically modified organisms or heterologous proteins/compounds in living system.

Reference Books:	
1.	Molecular Cell Biology, Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A and Martin K,WH Freeman; 8th edition, 2016, ISBN-10: 9781464187445
2.	Molecular Biotechnology – Principles and applications of recombinant DNA, Glick BR and Patten CL, ASM Press, 5th Edition. 2017. ISBN-13: 978-1555819361
3	Gene Cloning and DNA Analysis – An Introduction, Brown TA, Wiley-Blackwell Science, 7th Edition, 2015, ASIN: B018TJZNJ6.
4	Immunology and Immunotechnology, Ashim K. Chakravarthy, Oxford University Press. 2006.ISBN-10**:** 0195676882

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

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

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Continuous Internal Evaluation (CIE) for Practicals: (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 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.

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

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

Scheme of Semester End Examination (SEE); Practical (50 Marks)
SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

Semester: I		
COMPUTATIONAL GENOMICS AND PROTEOMICS (Theory and Practice)		
Course Code: 18 MBT 13		**CIE Marks:100+50**
Credits: L:T:P: 4:0:1		**SEE Marks:100+50**
Hours: : 44L+25P		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Understand the molecular aspects of the genome and dynamic models and regulatory networks at cellular level.
2	Develop the concepts and principles underlying the human genome project and plant genome program.
3	Differentiate between the different structures and functions of the proteome.
4	Get insights on protein identification and sequencing methods.

Unit-I	
Introduction: Introduction to Genomics& Proteomics. Structure, Organization and features of Prokaryotic &Eukaryotic genomes. Classification of genomics.DNA sequencing methods - Maxam-Gilbert Method, Sanger Dideoxy method, Fluorescence method, shot-gun approach and Microarray based sequencing. Next Generation Sequencing (NGS) and NGS Experimental Work Flow. NGS Platforms - Illumina Reverse Dye-Terminator, Ion Torrent Semiconductor sequencing and Pacific Biosciences Single Molecule Real-Time Sequencing. Genome databases – MGI, ZFIN, WormBase, BDGP &FlyBase, TIGR, MIPS, and Human Genome Database at NCBI and GOLD.	**09 Hrs**
Unit –II	
Genome annotation: Basic sequence alignment algorithms – Needleman and Wunch, Smith and Waterman. Gene prediction - Extrinsic, Intrinsic Signals. Algorithms - Exon chaining and Hidden Morkov Models (**Genie**). Computing Needs for NGS – Data storage, transfer, Computing power, Software needs and Bioinformatics Skills. NGS Data Analysis: Base calling and quality score, Data Quality Control and Preprocessing, Reads Mapping – Mapping approaches and algorithms, and Tertiary analysis. Case study – Genotyping and Genomics Variation Discovery by Whole Genome resequencing.	**09 Hrs**
Unit –III	
Methods of Proteomics: Edman degradation, mass fingerprinting, protein synthesis and post translational modifications. Identification of phosphorylated proteins, characterization of multiprotein complexes, protein - protein interactions (Immunoprecipitation) and quantitative proteomics- Characterization of interaction clusters using two-hybrid systems. Protein arrays definition, applications- diagnostics, expression profiling, Functional proteomics, Protein structure analysis, Clinical and biomedical applications of proteomics.	**09 Hrs**
Unit –IV	
Functional annotation of Proteins: Introduction, Protein sequence databases, UniProt, UniProtKB – Sequence curation, Sequence annotation, Functional annotation, annotation of protein structure, post-translational modification, protein-protein interactions and pathways, annotation of human sequences and diseases in UniProt and UniProtKB. Protein family classification for functional annotation – Protein signature methods and Databases, InterPro, InterProScan for sequence classification and functional annotation. Annotation from Genes and Protein to Genome and Proteome.	**09 Hrs**
Unit –V	
Genetic Circuits : Scope, Concepts and Applications, Current Progress inStatic and Dynamic Modeling of Biological networks, Models and Modeling in Genetic networking, Advantages of Computational Modeling, Modeling of Gene Expression- Lactose, LacOperon, tRNA. Analysis of Gene Expression Data- Support Vector Machines, Identifying Gene Regulatory Networks and Gene Expression Data. Modeling and Analysis of Gene Networks using Feedback Control. Global Gene Expression Assays, Interactomics in Network pharmacology and Toxicology.	**08 Hrs**

Unit-VI (Practical component)	25 Hrs
1. A. Fetching of DNA, RNA, and Protein sequences from GenBank, EMBL, DDBJ and SwissProt and navigation of NGS data. B. Retrieve the structure of macro and micro molecules from PDB, KEGG Drug and Pubchem compound and Navigation of Molecular structures. 2. A. Spectral alignment using MaxQuanta. B. Prediction of secondary and tertiary structure of proteins. 3. *A. de novo* Genome assembly. B. Differential gene expression analysis using transcriptomic data. 4. Network analysis using transcriptomic data. 5. Chip-Seq Analysis. A. QTL analysis. B. Identification of promoter sequences in the whole genome data. 6. Prediction of Genomic alterations in Cancer genome using Whole Genome Sequencing. 7. Protein-Ligand Docking Studies. 8. Modeling and Simulation of water permeation. 9. Modeling and Simulation of lipid bilayer. 10. Modeling and Simulation of DNA Sequencing using nanopores.	

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Understand the construction concepts of various genome maps and large scale sequencing
CO2:	Develop diagnostic tools for plant, animal and human diseases.
CO3:	Understand how proteomics application in biological research can benefit in solving the complex biological and biochemical processes regardless of the type of organism.
CO4:	Analyse dynamic models to understand the regulatory networks at cellular level.

Reference Books:	
3.	Systems Biology for Signaling Networks, Choi. S, Publisher-Springer, New York,2010. ISBN 978-1-4419-5796-2
4.	Computational Systems Biology: From Molecular Mechanisms to Disease, Kriete A, Eils R. 2nd Edition , Academic Press, 2013. ISBN 978-0-12-405926-9
3	Systems biology in practice: concepts, implementation and application, Klipp E, Herwig R, Kowald A, Wierling C, Lehrach H, Wiley-VCH Verlag GmbH &Co.KGaA,Weinhein 2005.ISBN 978-3-527-31078-4
4	Theoretical Models in Biology, Rowe G., Oxford University Press – Publisher,Oxford 1994. ISBN 0 19 859687 1.

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

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

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2)

seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Continuous Internal Evaluation (CIE) for Practicals: (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 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.

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

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

Scheme of Semester End Examination (SEE); Practical (50 Marks)
SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

Semester: I		
STEM CELLS AND TISSUE ENGINEERING (Group A: Core Elective)		
Course Code:18MBT1A1		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Know the types and applications of stem cells.
2	Learn techniques involved in isolation, selection and maintenance of stem cells.
3	Study the techniques used in growth and differentiation of tissues.
4	Acquire the methods for repairing of various kinds of tissues.

Unit-I	
Stem Cells: Concepts and Types of Stem cells: Embryonic, Adult and Induced stem cells. Embryonic stem cells: Pluripotent, Totipotent and Multipotent cells. Adult stem cells: Hematopoietic, Neural stem cells, Epidermal and Epithelial stem cell.	**07 Hrs**
Unit –II	
Growth and applications of 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 –III	
Introduction to 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.	**07 Hrs**
Unit –IV	
Basic growth and Differentiation of Tissues: Morphogenesis and tissue engineering-gene expression, cell determination and differentiation. In vitro control of tissue development: In vitro culture parameters, growth factors, mechanobiology, tissue development and organ engineering. In vivo synthesis of Tissue and Organs.	**07 Hrs**
Unit –V	
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. Biomaterials in tissue engineering.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explain the importance of stem cell, characteristics and tissue functions for specialized applications
CO2:	Compare various kinds of stem cells and tissues used for regeneration purpose.
CO3:	Interpret the methods used in organ regeneration.
CO4:	Apply techniques for growth of stem cells, and repairing various kinds of tissues.

Reference Books:	
1	Stem cell and Tissue Engineering, Song Li, Nicolas L' Heureux and Jennifer Elisseeff, world scientific publications, 2014, ISBN: 13978-981-4317-05-04
2	Principles of Tissue Engineering, R Lanza, Langer R and Vacanti J, Elsevier. 2013. ISBN: 978-0-12-398358-9
3	Tissue Engineering. John P. Fisher, A G Mikos and Joseph D Bronzino, CRC Press. 2007. ISBN: 0849390265
4	Tissue Engineering and Artificial organs, JD Bronzino, Taylor and Francis, 4th edition 2006, ISBN: 0849321239.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: I		
AGRICULTURAL BIOTECHNOLOGY AND SUSTAINABILITY (Group A: Core Elective)		
Course Code: 18MBT1A2		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Obtain a solid foundation in principles and fundamentals of plant and animal cell 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	
Concepts and scope of Agricultural Biotechnology: Tissue culture in crop improvement, Micropropagation. Meristem culture and production of virus-free plants. Haploids in plant breeding; Anther, microspore, embryo and ovary culture. Somatic hybridization; Protoplast isolation and fusion, cybrids. Somaclonal variation. Synthetic seeds. Cryopreservation, Secondary metabolites: production and elicitation with various biotic and abiotic elicitors.	**07 Hrs**
Unit –II	
Classical and molecular plant breeding: Breeding methods for self and cross pollinated crops. Conventional methods for crop improvement (Heterosis breeding, Mutation breeding, ploidy breeding). Self incompatibility and male sterility in crop breeding for crop improvement. Molecular Breeding: – Molecular tagging of genes/traits. Marker-assisted selection of qualitative and quantitative traits, Screening and validation; Trait related markers and characterization of genes involved, Gene pyramiding, Transcript mapping techniques.	**07 Hrs**
Unit –III	
Genetic Engineering for Crop Improvement: Manipulation of Photosynthesis, Nitrogen fixation, Nutrient uptake efficiency. Molecular mechanisms of biotic stress resistance (Insects, fungi, bacteria, viruses, weeds) and abiotic stress tolerance (drought and salt) plants. Genetic engineering for quality improvement of Protein, lipids, carbohydrates, vitamins & mineral nutrients, Concept of map-based cloning and their application in transgenics.	**07 Hrs**
Unit –IV	
Animal Biotechnology: Fundamentals of animal cell culture. Classical and Molecular breeding in animals, Marker assisted selection. Animal cloning; Transgenic animals, cloning of animals, Overview of Embryo Transfer in Farm Animals; Somatic Cell Nuclear Transfer and Other Assisted Reproductive Technologies. Basic principles for the production of transgenic fish, poultry breeds. Biosafety: Introduction to Biological Safety cabinets. Biosafety guidelines and Regulatory frameworks in India, GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in agriculture.	**07 Hrs**
Unit –V	
Biotechnology for Sustainable Agriculture: an overview, Biotechnological tools to enhance sustainable production, Sustainable agriculture and food security, Green food production, Green house technology and protected cultivation: Types of Green house, Various component of green house, Design, criteria and calculation. Green house irrigation system, Pytotrons: Hydroponics and aeroponics. Organic Farming: Concept of Integrated nutrient management and Integrated pest management, molecular farming in animals and plants. Nanotechnology and its implication in Agricultural Biotechnology.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Remember and explain various fundamentals of Agricultural Biotechnology with reference to breeding techniques and regulatory frameworks
CO2:	Apply the knowledge of modern tools to analyze the improvement of agricultural practices and

	livestocks
CO3:	Evaluate and analyze various parameters of transgenics for crop and livestock improvement
CO4:	Create paraphernalia for better usage and production of agri based products.

Reference Books:	
1	Agricultural Biotechnology, S SPurohit, Agribios India, 2nd ed. 2003, digitalized 2011, ISBN:81-7754-156-0.
2	Handbook on Agriculture, Biotechnology and Development, Stuart J. Smyth, Peter W.B. Phillips and David Castle, Edward Elgar Publications, 1st ed,2015 ISBN: 978178347 1355.
3	Plant Biotechnology-The genetic manipulation of plants, Adrian Slater, Nigel Scott and Mark Fowler, Oxford university press, 2nded, 2010, ISBN-13:9780199282616.
4	Plants, Genes, And Crop Biotechnology, Maarten J. Chrispeels and David E. Sadava , Jones and Bartlett Publishers, 2nd ed. 2003, ISBN-13: 978-0763715861.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: I		
SHELL SCRIPTING (Group A: Core Elective)		
Course Code: 18MBT1A3		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Explore conceptually Shell programming applications in the and study the role of computer science in life sciences.
2	Study basics of Linux and basic to advanced shell programming.
3	Understand the importance of shell programming to solve the problems related to Big Data Analytics in Bioinformatics.
4	Design and Explore Shell programming applications in NGS, Structural Bioinformatics and Computational Genomics and Proteomics.

Unit-I	
Unix basics: Introduction to Linux, basic commands, installing and uninstalling programs. Working with basic editors, pipes and wildcards. Working with processes; checking processes and killing processes. Working with files. Regular expressions.	**07 Hrs**
Unit –II	
Shell programming: Introduction to Shell scripting/programming, Variables, Special Variables, Operators, Arrays, and Statements.	**07 Hrs**
Unit –III	
Control structures in Shell: Conditional and looping statements in shell. if..then…fi, if…then…else…fi, if...elif..else…fi, case…in…esac. Looping structures – for…do…done, while…do…done, until…do…done. Syntax, usage and examples.	**07 Hrs**
Unit –IV	
Text processing with sed, awk and grep: Introduction tosed, awk and grep. Regular expressions in Sed, awk and grep. Working with parsing and processing of text.	**07 Hrs**
Unit –V	
High Performance Computing on Unix: Basic commands used in HPC cluster. HPC Data Storage, Serial and parallel batch jobs and scripting to run processes in parallel. Conversion of SRA files, FASTQC analysis using HPC – Command and tools required, interpretation of results. Adapter trimming, Alignment, Variant calling, Performing BLAST search, interpretation of results. Comparison of the results from various tools using HPC.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Eexplain and use the basic Unix commands used in File, Process, Memory, System and network management along with shell scripting.
CO2:	Apply basic Linux commands and shell programming skills to solve the problems in the area of Big Data Analytics.
CO3:	Analyze and evaluate the Linux based tools used in text processing, sequence and structure and NGS data analysis.
CO4:	Design and implement algorithms in using shell programming to perform high throughput data analysis in the field Sequence and structure analysis.

Reference Books:	
1	Shell Scripting: Learn Linux Shell Programming Step-By-Step (Bash Scripting, Unix), Harry Harvey, CreateSpace Independent Publishing Platform, 2017.
2	"Shell Scripting: Expert Recipes for Linux, Bash, and mor", Steve Parker, John Wiley and Sons, 2011.
3	"Shell Programming and Bash Scripting: Ultimate Beginners Guide Book", Robert Collins, CreateSpace Independent Publishing Platform, 2016.

4	Computational Biology: Unix/Linux, Data Processing and Programming, RöbbeWünschiers, Springer Science & Business Media, 2012.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: I		
HUMAN DISEASES (Group B: Core Elective)		
Course Code: 18MBT1B1		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Describe the processes that underlie the development of various diseases.
2	Explain the characteristics of and describe the basic mechanisms of pathogenesis
3	Understand the techniques involved in diagnostics of various types of disease
4	Understand the causes and therapeutics of various diseases

Unit-I	
Introduction to human diseases: Communicable disease and non-communicable disease. Genetic and congenital disease: sickle-cell anemia, hemophilia, colorblindness, down's syndrome. Deficiency disease: vitamin, hormone and mineral. Common screening methods for disease diagnosis.	**07 Hrs**
Unit –II	
Infectious Diseases: Overview of infectious diseases. Causes, diagnosis and therapeutics of infectious diseases: **Bacterial disease**: pneumonia, typhoid, tuberculosis, leprosy and cholera. **Viral disease**: influenza, dengue, chickenpox, human immunodeficiency virus. **Protozoan disease**: malaria and leishmaniasis. **Fungal disease**: ringworm and athlete's foot.	**07 Hrs**
Unit –III	
Diabetes Mellitus: Normal glucose and fat metabolism. Type I and type II diabetes: genetic and environmental predisposition, metabolic disturbances, symptoms, diagnosis and management. Gestational diabetes. Complications of diabetes- diabetic ketoacidosis, hypoglycemia, diabetic retinopathy and diabetic nephropathy.	**07 Hrs**
Unit –IV	
Cardiovascular diseases: Physiology of cardio vascular system. Causes, symptoms, diagnosis and therapeutics for ischaemic heart disease (IHD), hypertension, cerebrovascular disease (stroke), coronary artery disease, atherosclerosis, rheumatic heart disease and congenital heart disease.	**07 Hrs**
Unit –V	
Cancer: Genome instability and mutation, regulation of cell growth/proliferation, oncogenes, tumor suppressor genes, metastasis and complications. Cancer biomarkers. Diagnosis and therapeutics for cancer. Role of Virus in cancer.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explain the etiological factors of diseases
CO2:	Explain the causative factors of diseases
CO3:	Illustrate techniques of diagnosis for various human diseases.
CO4:	Discuss the causes and therapeutics of various diseases.

Reference Books:	
1	Principles and practice of medicine" Davidson, 22nd edition, 2014, Main Edition ISBN-13: 978-0-7020-5035-0, International Edition ISBN-13: 978-0-7020-5047-3, eBook ISBN-13: 978-0-7020-5103-6
2	Textbook of Preventive and Social Medicine, Mahajan & Gupta, 5th Edition, 2013, ISBN: 978-93-5090-187-8.
3	Textbook of Pathology, Harsh Mohan, Jaypee Brothers Medical Publishers., 6th Edition, 2013,

	ISBN 978-81-8448-702-2.
4	Oxford Textbook of Medicine,David A. Warrell, Timothy M. Cox, John D. Firth, Edward J., J R., M.D. Benz, Oxford Press, 6th Edition, 2014, ISBN: 9812-53-121-1.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: I		
ALTERNATIVE FARMING (Group B: Core Elective)		
Course Code: 18MBT1B2		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Study various techniques and processes in alternative farming.
2	Acquire the knowledge of organic farming and rooftop farming.
3	Know various kinds of technique involved in organic farming and rooftop farming.
4	Know various advanced techniques of immunotechnology, and genetic manipulation of microbes, plants and animals.

Unit-I	
Alternative farming: Marker-Assisted Breeding in Higher Plants, Phytoremediation Techniques for Pesticide Contaminations, Sustainable Land Use, Drought Stress Effect on Crop Pollination, Seed Set, Crop Yield and Quality. Ecological Fertilization, Arbuscular Mycorrhizal Fungi and Rhizobium to Control Plant Fungal Diseases, Sustainable Crop Production using Saline and Sodic Irrigation.	**07 Hrs**
Unit –II	
Organic farming I: Organic Food and Farming as a Prototype for Sustainable Agricultures, Soil Phosphorus Management in Organic Cropping Systems, Eco-functional Intensification by Cereal-Grain Legume Intercropping in Organic Farming Systems for Increased Yields, Reduced Weeds and Improved Grain Protein Concentration, Biocontrol: Principles and Implementation in Organic Farming, Agroecological Crop Protection in Organic Farming: Relevance and Limits, Regulatory Framework for Plant Protection in Organic Farming.	**07 Hrs**
Unit –III	
Organic farming II: Animal Healthcare Strategies in Organic and Conventional Farming, Optimisation of Breeding Systems and Land Use to Maximise Feed Self-Sufficiency and Economic Outcomes in Organic Sheep-for-Meat Production, Alternatives to Synthetic Chemical Antiparasitic Drugs in Organic Livestock Farming. Experiencing Organic Mixed Crop Dairy Systems: A Step-by-Step Design Centred on a Long-term Experiment, The Potential of Organic Agriculture to Mitigate the Influence of Agriculture on Global Warming, Food Quality and Possible Positive Health Effects of Organic Products.	**07 Hrs**
Unit –IV	
Rooftop farming I: Rooftop Farming Policy, Elements of Rooftop Agriculture Design, Soil Based and Simplified Hydroponics Rooftop Gardens,Rooftop Gardening for Improved Food and Nutrition Security in the Urban Environment, Biodiversity of Flora and Fauna, Resource Efficiency and Waste Avoidance.	**07 Hrs**
Unit –V	
Rooftop farming II: Rooftop Aquaponics, Technology for Rooftop Greenhouses, Integrating Rooftop Agriculture into Urban Infrastructure, Water Management and Irrigation Systems, Managing Mineral Nutrition in Soilless Culture, Sustainable Pest Management, Produce Quality and Safety.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explain various processes involved in alternative farming.
CO2:	Apply ecofriendly solutions to protect crop, water and soil from contamination with chemical fertilizers, pesticides and fungicides.
CO3:	Analyze and evaluate crops produced using alternative farming.
CO4:	Design/develop suitable methods/techniques for effective utilization of water and soil.

Reference Books:

1	Alternative Farming Systems, Biotechnology, Drought Stress and Ecological Fertilisation, 2011, Lichtfouse, Eric (Ed.), ISBN 978-94-007-0186-1
2	Organic Farming, Prototype for Sustainable Agricultures, Bellon, Stephane, Penvern,Servane (Eds.), Springer, 2014, ISBN 978-94-007-7927-3
3	Ed.), Organic Farming for Sustainable Agriculture, Nandwani,Dilip, Springer, 2016, ISBN 978-3-319-26803-3
4	Rooftop Urban Agriculture, Orsini, F., Dubbeling, M., de Zeeuw, H., Gianquinto, G. (Eds.), Springer, 2017, ISBN 978-3-319-57720-3

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: I		
SYSTEMS BIOLOGY **(Group B: Core Elective)**		
Course Code: 18MBT1B3		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Describe the main principles of systems biology and compare/contrast systems approaches to reductionist approaches in biology.
2	Explain the purpose and main principles of bioinformatics, how bioinformatics relates to systems biology, and the types of questions that can be answered using bioinformatics.
3	Identify the main types of biological network models used in systems biology, the types of high-throughput measurements on which they are based, and the types of predictions that can be derived from them.
4	Explain how systems biology can be used to improve our understanding of gene regulation, cancer, host/microbe interactions, metabolism, and immunology.

Unit-I	
Introduction to Systems Biology: Scope, Applications. Concepts, implementation and application. Databases for Systems Biology, Mass Spectrometry and systems Biology	**07 Hrs**
Unit –II	
Modeling Tools: SBML, MathML, CellML, Petri Nets and Bioinformatics.	**07 Hrs**
Unit –III	
Network Models and Applications: Natural Language Processing and Ontology enhanced Biomedical data mining, text mining.. Integrated Imaging Informatics - ntegrin, 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.	**07 Hrs**
Unit –IV	
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.	**07 Hrs**
Unit –V	
Multiscale representations of cells and Emerging phenotypes: Multistability and Multicellurarity, Spatio-Temporal systems biology, Cytomics – from cell state to predictive medicine.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explain conceptually systems biology using Biological data
CO2:	Apply computational tools and techniques to solve problems in the field of Proteomics, Genomics, Cancer biology as well as Immunology
CO3:	Analyze and evaluate High Throughput Data generated by sequencing/mapping/hybridization and other projects using Clustering and searching algorithms with case studies
CO4:	Design and execute protocols to perform high throughput data analysis in the field of Proteomics, Genomics, Cancer biology as well as Immunology

Reference Books:	
1	Computational Systems Biology, Andres Kriete, Roland Eils. Academic Press, 2006.
2	Systems Biology, Andrzej K. Konopka, CRC, 2006.
3	Evolutionary Genomics and Systems Biology, Gustavo Caetano-Anollés, John Wiley & Sons, 2011. ISBN-13: 9781118210710
4	Elements of Computational Systems Biology, Huma M. Lodhi, Stephen H. Muggleton, John Wiley & Sons, 2010. ISBN-13: 9780470556740

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: I						
PROFESSIONAL SKILL DEVELOPMENT (Common to all Programs)						
Course Code	**:**	**18HSS14**		**CIE Marks**	**:**	**50**
Credits: L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**Audit Course**
Hours	**:**	**18L**				

Unit – I	**03 Hrs**
Communication Skills: Basics of Communication, Personal Skills & Presentation Skills – Introduction, Application, Simulation, Attitudinal Development, Self Confidence, SWOC analysis. **Resume Writing:** Understanding the basic essentials for a resume, Resume writing tips Guidelines for better presentation of facts. Theory and Applications.	
Unit - II	**08 Hrs**
Quantitative Aptitude and Data Analysis: Number Systems, Math Vocabulary, fraction decimals, digit places etc. Simple equations – Linear equations, Elimination Method, Substitution Method, Inequalities. **Reasoning** – a. **Verbal** - Blood Relation, Sense of Direction, Arithmetic & Alphabet. b. **Non- Verbal reasoning** - Visual Sequence, Visual analogy and classification. **Analytical Reasoning** - Single & Multiple comparisons, Linear Sequencing. **Logical Aptitude** - Syllogism, Venn-diagram method, Three statement syllogism, Deductive and inductive reasoning. Introduction to puzzle and games organizing information, parts of an argument, common flaws, arguments and assumptions. **Verbal Analogies/Aptitude** – introduction to different question types – analogies, Grammar review, sentence completions, sentence corrections, antonyms/synonyms, vocabulary building etc. Reading Comprehension, Problem Solving	
Unit - III	**03 Hrs**
Interview Skills: Questions asked & how to handle them, Body language in interview, and Etiquette – Conversational and Professional, Dress code in interview, Professional attire and Grooming, Behavioral and technical interviews, Mock interviews - Mock interviews with different Panels. Practice on Stress Interviews, Technical Interviews, and General HR interviews	
Unit - IV	**02 Hrs**
Interpersonal and Managerial Skills: Optimal co-existence, cultural sensitivity, gender sensitivity; capability and maturity model, decision making ability and analysis for brain storming; Group discussion(Assertiveness) and presentation skills	
Unit - V	**07 Hrs**
Motivation: Self-motivation, group motivation, Behavioral Management, Inspirational and motivational speech with conclusion. (Examples to be cited). **Leadership Skills:** Ethics and Integrity, Goal Setting, leadership ability.	

Course Outcomes: After going through this course the student will be able to:	
CO1	Develop professional skill to suit the industry requirement.
CO2	Analyze problems using quantitative and reasoning skills
CO3	Develop leadership and interpersonal working skills.
CO4	Demonstrate verbal communication skills with appropriate body language.

Reference Books:	
1.	The 7 Habits of Highly Effective People, Stephen R Covey, 2004 Edition, Free Press,ISBN: 0743272455
2.	How to win friends and influence people, Dale Carnegie, 1st Edition, 2016, General Press, 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.	Ethnus, Aptimithra: Best Aptitude Book, 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**
I	After 9 hours of training program, students are required to undergo a test set for a total of 50 marks. The structure of the test will have two parts. Part A will be quiz based evaluated for 15 marks and Part B will be of descriptive type, set for 50 Marks and reduced to 35 marks. The total marks for this phase will be 50 (15 + 35).
II	Similarly students will have to take up another test after the completion 18 hours of training. The structure of the test will have two parts. Part A will be quiz based evaluated for 15 marks and Part B will be of descriptive type, set for 50 Marks and reduced to 35 marks. The total marks for this phase will be 50 (15 + 35).
FINAL CIE COMPUTATION	
Continuous Internal Evaluation for this course will be based on the average of the score attained through the two tests. The CIE score in this course, which is a mandatory requirement for the award of degree, must be greater than 50%. Needless to say the attendance requirement will be the same as in any other course.	

Semester: II		
UPSTREAM PROCESS TECHNOLOGY (Theory and Practice)		
Course Code: 18 MBT21		**CIE Marks:100+50**
Credits: L:T:P: 4:0:1		**SEE Marks:100+50**
Hours: : 44L+25P		**SEE Duration:3Hrs**
Course Learning Objectives:		
1	Study various microbial, plant and animal cell culture techniques.	
2	Acquire knowledge of advanced techniques used in the production of heterologous compounds/GMOs	
3	Use proper technique to enhance the production of compounds/heterologous products in biological system.	
4	Evaluate cultures and products developed from biological systems.	

Unit-I	
Introduction: Plant tissue culture; Plasticity and Totipotency,Micropropgation; Organogenesis and somatic embryogenesis, Gene regulation during somatic embryogenesis. Somatic hybridization and cybridization, Somaclonal variation, Cryopreservation. Growth and production kinetics of cell cultures, Biotic and abiotic elicitation, Biotransformation. Laboratory safety, Risk assessment, Standard operating systems, Biohazards, Bioethics and Validation, Issues and concerns, biosafety, societal and ethical aspects of genetically modified foods and crops.	**09 Hrs**
Unit –II	
Application of transgenic plants: Molecular farming/pharming- Golden rice. Modified Plant lipids, carbohydrates and proteins, bioplastics, Genetic manipulation of fruit ripening. **Omics in Plant world:** Interrelationships of omic disciplines. Identifying genes of interest through genomic studies. Plant Cyc databases. RNAi for Crop Improvement. Advanced genetic tools for plant biotechnology; plant genome editing- (CRISPR)/CRISPR-associated protein 9 (Cas9) system, Zinc finger nucleases (ZFNs), meganucleases and transcription activator-like effector nucleases (TALENs).	**09 Hrs**
Unit –III	
Animal Cell Culture Technology:, origin of concept, Cell lines and their applications. Types of culture media, Primary culture, stem cells, epithelial cells, Hemopoitic cells and cryopreservation, Amniocentesis, Oncofetal antigens, 3D culture, Production of Hybridomas- Immunotoxins, , Inerferons Tumour immunology, Gene Therapy- Prospects and problems; Knockout mice and mice model for human genetic disorder. Strategies for gene transfer in animal cells; mechanisms of transfection, vectors used in transfection. Artificial insemination, In vitro fertilization and embryo transfer. Ethical issues related to transgenic animals, Human tissue cell and products.	**09 Hrs**
Unit –IV	
Microbial Biotechnology: Microbial Production flow sheet, Microbial Metabolites and recombinant products, Strain development by various methods, Production of therapeutic agents, Microbial insecticides- Cry (Bt) proteins, Enzymes-Alginate lyase and restriction endonucleases, **Microbial products in beverage and food industry:** Acids- Citric and lactic acid. Biopolymers (Xanthan gum). Fermented foods (yoghurt and cheese). Degradative capabilities of microorganisms, Degradation of xenobiotics, Genetic engineering of biodegradative pathways (Manipulation by transfer of plasmids and by gene alteration), Production of Biofuels (ethanol, methane).	**09 Hrs**
Unit –V	
Bioreactors, Mode and mechanism of fermentation-Batch, continuous, Fed batch, Optimisation of fermentation, microbiology of brewing Beer and wine, Nutrient cycling, use of microbes in industrial waste treatment, microbial leaching, utilizing GE organisms for bio	**08 Hrs**

processing. Fermentation media- Measurement of temperature, pressure, pH, Dissolved Oxygen, foam, product activity, substrate concentration and critical components and agitation control. Measurement of flow rate of liquid and gases; online estimation of process parameters.	

Unit-VI (Practical component)	**25 Hrs**
1. Initiation of cell suspension culture using explants of medicinal plants. 2. Elicitation of secondary metabolites in callus using various elicitors. 3. Extraction of secondary metabolites from callus culture and its estimation. **4.** Production of antibiotics from bacterial and fungal species and study its inhibition activity. 5. Production Pectinase from microbial cultures and estimation of its activity. 6. Production of cellulase from microbial cultures and estimation of its activity. 7. Production of proteases from microbes and estimation of its activity. 8. Production of ethanol using agriculture/horticulture waste. 9. Isolation of primary cell lines and its maintenance. 10. Cell viability study by trypan blue dye.	

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explain the technique/processes involved in culturing of microbial, plant and animal cells.
CO2:	Apply modern techniques to produce clones/heterologous compounds/genetically modified organisms.
CO3:	Screen and Analyse the products/heterologous compounds/genetically modified organisms.
CO4:	Design/develop methodology for production of clones/compounds/genetically modified organisms.

Reference Books:	
1	Plant Biotechnology and Genetics: Principles, Techniques, and Applications. Neal Stewart C Jr., Wiley publishers. 2nd Edition. 2016.ISBN: 9781118820124.
2	Plant Biotechnology: The genetic manipulation of plants, Mark R. Fowler, Adrian Slater, Nigel W. Scott. Oxford University Press. 2nd Edition. ISBN: 9780199560875.
3	Microbial Biotechnology: Fundamentals of applied microbiology, Glazer AN, Nikaido, Cambridge University Press, 2nd Edition, 2007, ISBN 978-0-52184210-5.
4	Cell Culture and Upstream Processing, Michael Butler, Garland science publisher, 2007.

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

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Continuous Internal Evaluation (CIE) for Practicals: (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 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement

additional innovative experiments in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.

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

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

Scheme of Semester End Examination (SEE); Practical (50 Marks)
SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

Semester: II		
PHARMACEUTICAL TECHNOLOGY		
Course Code: 18MBT22		**CIE Marks:100**
Credits: L:T:P: 4:0:0		**SEE Marks:100**
Hours: : 44L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Develop an appreciation and understanding to the pharmaceutical research and development.
2	Determine parameters related to stability and formulation of biopharmacetical products.
3	Acquire the knowledge of drug dose relationship and mechanism of action of drugs
4	Understand and evaluate the different pharmaceutical products and their effects on mankind.

Unit-I	
Introduction: Configuration and conformation of drug molecules, rational drug design, various approaches in drug discovery, drug targets and pharmacophores. Physical properties of drugs - physical form, polymorphism, particle size, shape, density, dielectric constant, solubility, dissolution, organoleptic property and their effect on formulation. Drugs & Cosmetic Act. cGMP concepts – Development, Manufacturing Record, Analytical & process Validation, Regulatory bodies & requirements - Indian FDA, WHO GMP,USFDA. Schedule-Y. Pre-clinical study requirements, clinical trial phases, Types of trials and Bioethics, Bioavailability and Bio equivalance studies. Details on Pharmacopoeia.	**08 Hrs**
Unit –II	
Molecular Modeling in Drug Discovery: Drug discovery process, Lipinski "rule of 5", Partition coefficient, Hammet constant, Hansch analysis. Role of Bioinformatics in drug design. Target identification and validation, lead optimization and validation, Structure and ligand based drug design, Modeling of target-small molecule interactions, Molecular Simulations, Protein modeling. Structure Activity Relationship - QSARs and QSPRs, QSAR Methodology, Various Descriptors used in QSARs	**08 Hrs**
Unit –III	
Drug Pharmacokinetics and Pharmacodynamics: Principles of basic and clinical pharmacokinetics and pharmacodynamics. Physiology of the absorbing membranes. Mechanisms of drug absorption - passive and active transport - Fick's first law - effect of membrane permeability on oral absorption. Factors affecting bioavailability-Physiological, Adverse drug reactions. Drug interactions, Bioassay of drugs and biological standardization of immunogers. **Routes:** Oral, Sublingual, Buccal, Parenteral, Topical, Rectal and Inhalation. The pharmacokinetic implications of various routes of administration- Advantages and Disadvantage of various routes of administration.	**10 Hrs**
Unit –IV	
Introduction to Vaccinology Classification, active immunization, means of passive immunization, antibodies in therapy, antibody engineering, monoclonal antibodies, immunoconjugates - specific drug targeting, immunotoxins. **Immuno-Therapeutics: De**velopment of immuno-drugs. Cytokines classification, pathways of activation, Therapeutic use of cytokines. Immunomodulators classification, thymic hormones and synthetic immunostimulators. Compliment pathways diagnostics, ELISA, Flow cytometry, ELISPOT, immuno radiology, Basic immunotoxicology - Principles of testing of immunomodurating drugs and Xenobiotics	**10 Hrs**
Unit –V	
Drug Pharmacology: Chemical transmission and drug action in the CNS. Diuretics, Drugs altering the pH of urine, excretion of organic molecules.Molecular Cardiology: Congenital Heart Disease, Inherited Cardiomyopathies, Coronary Atherosclerosis, Derived Nitric Oxide and Control of Vascular Tone, Hypertension, Cardiac Arrhythmias, Cardiovascular Gene Therapy. **Pulmonology:** Asthma, Pulmonary Emphysema. Lung Cancer: The Role of Tumor Suppressor Genes – Strategies for controlling the diseases. **Drugs acting on GIT:** Antacids and anti-ulcer drugs, Laxatives and Anti-diarrheal drugs,	**08 Hrs**

Appetite stimulants and suppressants, Emetics and anti-emetics. Thyroid hormones and anti-thyroid drugs ACTH and corticosteroids, Androgens and anabolic steroids, oral contraceptives. Treatment of poisoning, Heavy metals and heavy metal antagonists, Acute, Sub acute and Chronic toxicity	

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Understand the effects and mechanism of action of pharmaceutical products.
CO2:	Evaluate the quality of pharmaceutical products and discuss the impact of pharma-products
CO3:	Apply knowledge/theory to new situations e.g. the formulation of hypotheses and experimental design.
CO4:	Describe approved biotech products, e.g., indications, advantages, disease impact, & product limits, & status of pipeline products, e.g., development issues

Reference Books:	
1	Pharmaceutical Biotechnology: Fundamentals and Applications, Daan J. A. Crommelin, Robert D. Sindelar, Bernd Meibohm, Springer Science & Business Media, 2013. ISBN: 1461464862, 9781461464860
2	Feuerstein Pharmaceutical Biotechnology, Carlos A. Guzmán, Giora Z. Volume 655 of Advances in Experimental Medicine and Biology, Springer Science & Business Media, 2010. ISBN: 1441911324, 9781441911322
3	Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, Oliver Kayser, HeribertWarzecha, John Wiley & Sons, 2012, ISBN: 352765125X, 9783527651252
4	Goodman and Gilman's Manual of Pharmacology and Therapeutics. Laurence L. Brunton, RandaHilal-Dandan,McGraw Hill Professional, 2013. ISBN: 007176917X, 9780071769174

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: II		
RESEARCH METHODOLOGY		
Course Code:18 IEM 23		**CIE Marks:100**
Credits: L:T:P: 3:0:0		**SEE Marks:100**
Hours: : 36L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Have a basic understanding of the underlying principles of quantitative and qualitative research
2	Identify the overall process of designing a research study from its inception to its report.
3	Gain a overview of a range of quantitative and qualitative approaches to data analysis
4	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.
5	To equip students on the need to protect their own intellectual works and develop ethical standards governing ethical works.

Unit-I	
Overview of Research: Research and its types, identifying and defining research problem and introduction to different research designs. Essential constituents of Literature Review. Basic principles of experimental design, completely randomized, randomized block, Latin Square, Factorial.	**07 Hrs**
Unit –II	
Data and data collection: Overview of probability and data typesPrimary data and Secondary Data, methods of primary data collection, classification of secondary data, designing questionnaires and schedules. **Sampling Methods:** Probability sampling and Non-probability sampling	**08 Hrs**
Unit –III	
Processing and analysis of Data: Statistical measures of location, spread and shape, Correlation and regression, Hypothesis Testing and ANOVA. Interpretation of output from statistical software tools	**07 Hrs**
Unit –IV	
Advanced statistical analyses: Non parametric tests, Introduction to multiple regression, factor analysis, cluster analysis, principal component analysis. Usage and interpretation of output from statistical analysis software tools.	**07 Hrs**
Unit –V	
Essentials of Report writing and Ethical issues: Significance of Report Writing ,Different Steps in Writing Report,Layout of the Research Report , Ethical issues related to Research, Publishing, Plagiarism. **Case studies:** Discussion of case studies specific to the domain area of specialization	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explain the principles and concepts of research types, data types and analysis procedures.
CO2:	Apply appropriate method for data collection and analyze the data using statistical principles.
CO3:	Present research output in a structured report as per the technical and ethical standards.
CO4:	Create research design for a given engineering and management problem situation.

Reference Books:	
1	Research Methodology Methods and techniques, Kothari C.R., by, New Age International Publishers, 4th edition, ISBN: 978-93-86649-22-5
2	Management Research Methodology, Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M.,, Pearson Education: New Delhi, 2006. ISBN: 978-81-77585-63-6
3	Statistics for Management, Levin, R.I. and Rubin, D.S., 7th Edition, Pearson Education: New Delhi.
4	

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: II		
BIOMEDICAL INSTRUMENTATION AND DIGITAL HEALTH (Group C: Core Elective)		
Course Code:18MBT2C1		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	This subject will enable the students to study the basic principles of different instruments/equipment used in the health care industry
2	To study the topics including general types of devices, fundamental principles of operation, and quantitative analysis methods for understanding and designing Biomedical Instruments
3	To study, analyze and evaluate the effect of different diagnostic and therapeutic methods, their risk potential, physical principles, opportunities and possibilities for different medical procedures.
4	To study the Image analysis developed from the MRI and X-ray technique.

Unit-I	
Introduction To Biomedical Instrumentation: Sources of biomedical signals, basics of medical instrumentation system, different bioelectrical signals. Transducers: Definition, classification and biomedical application. Biopotential Electrodes, Resting and Action potential, Propagation of Action potential, bioelectric potentials.	**07 Hrs**
Unit –II	
Cardiovascular Measurements: Anatomy of heart, cardiac cycle, circulation of the blood, Measurement of blood pressure, blood flow characteristics, genesis and characteristics of Electrocardiogram (ECG) and its Block diagram description, lead configuration and recorders.	**07 Hrs**
Unit –III	
Central Nervous System: Electrical activity of CNS, genesis and characteristics of an Electroencephalogram (EEG) and its Block diagram description. **Respiratory System:** Methods for Measurements of Respiration rate: Thermistor, Impedance puenmography. Blood gas (pCO_2 and pO_2) analyzers. Ventilators, Anesthesia machines, Heart lung machine	**07 Hrs**
Unit –IV	
Therapeutic Equipments: 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.	**07 Hrs**
Unit –V	
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, Phase encoding, frequency encoding and K-space formation, Clinical application of MRI. Bedside Diagnostic tests- Biotechnology based kits and optic fibers use in medical devices.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Understand the working principles of instruments used for diagnostics of human diseases.
CO2:	Evaluate the effect of different diagnostics and therapeutic methods.
CO3:	Measure and diagnose the risk potentials of human health.
CO4:	Develop the diagnostic techniques to evaluate the human disease.

Reference Books:

1	Biomedical Instrumentation and Measurements, Anandanatarajan.R., PHI Pub. 2011. ISBN:978-81-203-4227-9.
2	Biomedical Instrumentation Technology and Applications, Khandpur R.S., McGraw –Hill Pub. 2004.ISBN-9780071777469
3	Biomedical Instrumentation Systems, Shakti. Chatterjee, Aubert Miller.. Delmar cengage learning Pub.2010.ISBN:139781418018665
4	Introduction to Biomedical Instrumentation. Mandeep Singh., PHI Pub., 2010. ISBN: 9788120341630.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: II		
CROP IMPROVEMENT AND MOLECULAR BREEDING (Group C: Core Elective)		
Course Code: 18MBT2C2		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Based on our knowledge of genetics and molecular genetics to acquaint students with traditional and modern breeding methods
2	Procedures point to the potential use of genetic varieties.
3	Procedures involved in practical plant breeding.
4	Focuses on using the latest molecular techniques

Unit-I	
Introduction and basic concepts of classical plant breeding: The status of plant breeding in agriculture, the importance of breeding, history and development of plant breeding in the world. Genetic structure of the variety, variability of cultivated plants, important cultural properties and characteristics of flora. The main phases of the breeding process, genetic resources, centers of origin of cultivated plants, preservation and conservation of genetic resources. Implications for the propagation of breeding methods and selection procedures, techniques and procedures for crossing	**07 Hrs**
Unit –II	
Conventional techniques, methods and practices of breeding: The techniques and selection methods. Breeding methods for self, cross-pollinated, and in vegetatively propagated crops. Peculiarities of the biennial and perennial species. Nature and theory of heterosis, using heterózního effect in plant-breeding techniques for the breeding of F1 hybrids. Male sterility, genetic determination of male sterility, the use of male sterility in breeding of F1 hybrids.	**07 Hrs**
Unit –III	
Alternative breeding techniques: Mutation breeding, induced mutagenesis, mutagens used, methods of working. Remote hybridization causes problems with pollination of species and the possibility of overcoming, the properties of distant hybrids. Properties of polyploids, the use of polyploidy in plant breeding, methods of obtaining polyploid breeding, use of aneuploidy. Haploids in plant breeding. Breeding for resistance to pests and diseases, genetic nature of resistance.	**07 Hrs**
Unit –IV	
Molecular markers, Their Nature and Use: Hybridization techniques used to detect molecular markers. RFLP, VNTR, FISH and more. Techniques based on polymerase chain reaction (PCR): RAPD, SSR, AFLP. Methods for DNA sequencing. The use of molecular markers to analyze genetic resources (genotyping) and using selection markers (marker assisted selection, MAS)	**07 Hrs**
Unit –V	
Gene manipulation in plant breeding : The basic strategy of gene manipulation in plants, gene cloning and cloning vectors, expression vectors. The use of *Agrobacterium tumefaciens* in transgenosis plants, other technologies can obtain genetically modified plants. Objectives for Transgenosis in plants, most frequently used genes, characteristics of the GMOs, placing GMOs in the market. Legislation governing the handling of GMOs.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	The ability to draw conclusions applicable in breeding from the results of molecular analysis.
CO2:	Apply techniques to produce and select hybrid plants.
CO3:	The ability to propose an approach for the desired properties of the plants with the classical and biotechnological methods.

CO4:	The ability to select a suitable molecular marker for the plant species for the MAS (Marker Assisted Selection)

Reference Books:	
1	Principles of Crop Improvement by N.W. Simmonds and J. Smart
2	Principles of Cultivar Development, Vol. 1 Theory and Technique by W. R. Fehr
3	Selection Methods in Plant Breeding. Bos I &Caligari P. 1995. Chapman & Hall.
4	Molecular Breeding for Sustainable Crop Improvement, Vijay Rani Rajpal, S. Rama Rao, S.N. Raina, Vol.2., 2016, Springer International Publishing Switzerland, 978-3-319-27090-6

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

Semester: II		
INSILICO DRUG DESIGN (Group C: Core Elective)		
Course Code: 18MBT2C3		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Understand the underlying principles of molecular modeling and simulation involved in drug design and discovery.
2	Explore conceptually the techniques employed in Model building, Library design and Molecular interaction studies
3	Synchronize computational tools and techniques to empower the insights and advances in the field of Pharmacy
4	Apply Evolutionary, Machine leaning and numerical techniques to cope up with the current picture in pharmaceutical research.

Unit-I	
Drug Design Process: Computer - Assisted Drug Discovery: Drug Discovery and Development process. Compound searching, Target Identification, Target characterisation, Study of molecular interactions between target and compound (docking), ADMET Studies and Study of drug resistance. Drug design process for a known protein target – Structure based drug design process, Finding initial hits, Compound refinement, ADMET Studies and Study of drug resistance. Drug design process for unknown protein target – Ligand based drug design process, Finding initial hits, Compound refinement, ADMET Studies and Study of drug resistance. Case studies	**07 Hrs**
Unit –II	
Compound Library Design: Target library vs Diverse libraries, Non-Enumerative techniques, Drug likeliness and Synthetic accessibility, Analyzing diversity and Spanning known chemistries. Compound selection techniques.	**07 Hrs**
Unit –III	
Homology Modeling and Drug Design: Structure Generation, Retrieval, Structure Visualization. Homology modeling - Constructing an initial model, Refining the model, Manipulating the model, Navigation of the model. Model evaluation – Model evaluation techniques, Concept of energy minimization and Energy minimization techniques. Conformation generation, Deriving bioactive conformations, Molecular superposition and alignment, Deriving the Pharmacophoric pattern, Receptor mapping and estimating biological activities. Structural similarities and Superimposition techniques. Rational Drug Design and Chemical Intuition, Important Key and the Role of the Molecular Model, Limitations of Chemical Intuition.	**07 Hrs**
Unit –IV	
Molecular Mechanics: Introduction to Molecular mechanics, Force fields for drug design. Study of protein folding: Algorithms, Conformation analysis. Docking: Introduction, Search algorithms, Scoring functions, Docking Process – Protein Preparation, Building the ligand, Setting the bounding box, Running the docking calculations. Building the Pharmacophore Models: Components of Pharmacophore model, Creating a Pharmacophore model from active compounds, Creating Pharmacophore model from Active site and Searching compound databases.	**07 Hrs**
Unit –V	
Quantum Mechanics in Drug Design: QSAR: Conventional QSAR vs 3D-QSAR, QSAR Process, Molecular descriptors, Automated QSAR Programs. 3D-QSAR – 3D-QSAR Process. Quantum Mechanics algorithms in Drug design, ADMET and Toxicity studies. New Lead Discovery Strategies. Composition of Drug Discovery teams, Current Practice of CADD in the Pharmaceutical industry, Management structures of CADD groups, Contributions and achievements of CADD groups, Limitations of CADD support, Inherent	**08 Hrs**

Limitations of CADD support. State of Current Computational Models, Software and Hardware constraints	

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Demonstrate the knowledge of physical and chemical properties of pharmacological compounds.
CO2:	Apply the drug designing methods for screening and inventing the new targets and drugs.
CO3:	Estimate the relevant drug capabilities of known and unknown compounds.
CO4:	Equip with the drug design skills and patenting ability and spread awareness about the compounds.

Reference Books:	
1	Cancer Drug Design and Discovery, Stephen Neidle, Academic Press – Publisher,2008.ISBN 0123694485, 9780123694485
2	Bioinformatics Technologies, Yi-Ping Phoebe Chen, Springer Science & Business Media, 2005. ISBN 354026888X, 9783540268888
3	Textbook of drug design and discovery, Kristian Stromgaard, PovlKrogsgaard-Larsen, Ulf Madsen, 5thedition. Published by CRC Press, LLC, 2016. ISBN1498702783, 9781498702782
4	Computational Drug Design: A Guide for Computational and Medicinal Chemists,David. C. Young, Wiley-Interscience, 2009. ISBN: 978-0-470-12685-1

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: II		
MEDICAL IMPLANT AND DEVICES (Group D: Core Elective)		
Course Code: 18MBT2D1		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:
Students are able to:

1	Understand the principles, applications and purpose of using medical devices and implants which mimic natural organs..
2	Gain the knowledge of design and use of engineering devices used for oral and orthopaedic problems.
3	Acquire knowledge on use of medical devices in Cardiovascular, Optical and auditory systems.
4	Understand the design and application of sensor based wearable medical devices through information technology.

Unit-I	
Introduction and Oral implants: Introduction to medical implants and prosthetics used to mimic natural body organs or parts. The requirement of implants and various materials used to make implants. **The implants related to oral problems:** The jaw replacement, artificial single tooth and full denture, palate replacement.	**07 Hrs**
Unit –II	
Orthopaedic implants: The Implant to correct the problems related to bones, various types of material used to make artificial bone for natural bone replacement. The limbs bones and support implant or full bone replacement methods. The knee replacement, types of material to make artificial knee and surgical method to implant. The partial or full hip bone replacement.	**07 Hrs**
Unit –III	
Cardiovascular implants: The common problems related to cardiovascular system which are being routinely corrected using artificial implants. The various types of "Stents" used for arterial blockages. The implant of pace maker for heart to monitor and form the correct pace for heart breathing. The heart valves to replace damaged or incorrect valves in heart. The complete artificial heart device in case of total failure of heart functioning.	**07 Hrs**
Unit –IV	
Auditory and Optical implants: **Auditory implants:** hearing aids, external ear for the cosmetic purpose, the middle ear and cochlea implant to correct the sense of hearing. **Vision implants:** For the correction of vision related to focal length the lenses and contact lenses. The replacement of opaque lens due to cataract by artificial lens. The recent advances in retina replacement	**07 Hrs**
Unit –V	
Noninvasive Wearable Medical devices: Purpose, design, signal, data storage, data integration into information technology and work flow related to following devices: Overall health record, Stay Fit and Energetic, Continuous Glucose Monitors (CGM) together with release of Insulin, Cardiac Monitoring Device	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explain the principle of, design and material used in making of various medical devices.
CO2:	Apply the knowledge for making devices having application in oral and orthopaedic field.
CO3:	Design, and apply the medical devices in the cardiovascular, auditory and optical sector.
CO4:	Understand and evaluate the principles of the use of IoT and Cloud Server based wearable health sensors monitoring system.

Reference Books:	
1	Biomimetics: Biologically Inspired technologies, Yoseph Bar-Cohen, 2005, CRC press, ISBN: 9780849331633
2	Biomimetics-Nature Based Innovation, Yoseph Bar-Cohen, 2011, CRC press, ISBN: 9781439834763
3	Bio inspired Engineering, Jenkins, C.H., NY: Momentum press, 2012 ISBN: 97816066502259
4	Human Physiology C.C.Chatterjee, Volume 1 (11th Edition), 2016, ISBN 10: 8123928726 / ISBN 13: 9788123928722.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments (A). A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: II		
FOOD TECHNOLOGY (Group D: Core Elective)		
Course Code: 18MBT2D2		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Understand the properties of food and techniques for food processing.
2	Illustrate the application of food preservation and food production with improved nutritional benefits
3	Analyze various modern tools and techniques for food processing and packaging.
4	Get an overview of probiotics, prebiotics and nutraceuticals.

Unit-I	
Properties of foods and processing theory: Properties of liquids, solids and gases, Fluid flow through fluidized bed, Mechanisms of heat transfer, Sources of heat and methods of application to foods, Energy conservation Effect of heat on micro-organisms, Effect of heat on nutritional and sensory characteristics, Water activity, Effects of processing on sensory characteristics of foods, Effects of processing on nutritional properties, Food safety, good manufacturing practice and quality assurance	**07 Hrs**
Unit –II	
Ambient-temperature processing: Raw material preparation: Cleaning, Sorting, grading, peeling. Size reduction: Size reduction of solid and liquid foods: theory, equipment and effects on food. Mixing and forming. separation and concentration of food components, Processing using electric fields: high hydrostatic pressure, light or ultrasound, irradiation: theory, equipment and effect on food.	**07 Hrs**
Unit –III	
Processing by application of heat (theory, equipment and effect on foods): Heat processing using steam or water, Blanching, Pasteurization, Heat sterilization, Extrusion, Heat processing using hot air(theory, equipment and effect on foods): Dehydration, Baking and roasting, Heat processing by direct and radiated energy: Dielectric, ohmic and infrared heating. Heat processing using hot oils: theory equipment and effects on food of frying	**07 Hrs**
Unit –IV	
Processing by the removal of heat: Chilling, Controlled- or modified-atmosphere storage and packaging, Freezing and concentration. Post-processing operations: coating or enrobing, Packaging: theory and types of packaging materials, Printing, Interactions between packaging and foods. Environmental considerations. Filling and sealing of containers: Rigid and semi-rigid containers, flexible containers, Types of sealer, Shrink-wrapping and stretch-wrapping, Tamper-evident packaging, Labelling, Materials handling, storage and distribution.	**07 Hrs**
Unit –V	
Prebiotics, probiotics and nutraceuticals: Food Pyramid, Concept of prebiotics and probiotics - principle, mechanism and applications of probiotics, prebiotics Synbiotics for maintaining good health. Source of omega - 3 fatty acids, formulations, bioavailability, bioequivalence, Commercialization and Potential of Nutrigenetics and Nutrigenomics	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Remember and apply the properties of food during processing of food
CO2:	Know the application of biotechnology for food preservation and food production with improved nutritional benefits.
CO3:	Acquire and apply various food processing techniques to increase the nutritional content and shelf life of food.
CO4:	Evaluate and analyze the current ongoing research in nutraceuticals.

Reference Books:	
1	Food Processing Technology: Principles and Practice, Fellows, P.J, Woodhead Publishing limited, Cambridge, 2nd edition, 2009. ISBN 978-1-84569-216-2
2	**Introduction to Food Engineering,** R. Paul Singh and Dennis R. Heldman, Academic Press, Elsevier, 5th ed., 2013.ISBN 9780123985309
3	Food Process Engineering Operations, George D. Saravacos and Zacharias B. Maroulis,, 1st ed. 201, CRC press, Taylor and Francis, ISBN- 13: 978-1-4200-8354-5
4	Nutrigenomics and Nutrigenetics in Functional Foods and Personalized Nutrition, Lynnette R. Ferguson, 2013 CRC Press ISBN 9781439876800

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

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

Semester: II		
HIGH PERFORMANCE COMPUTING (Group D: Core Elective)		
Course Code:18MBT2D3		**CIE Marks:100**
Credits: L:T:P: 3:1:0		**SEE Marks:100**
Hours: : 36L+12T		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Impart the basic concepts of High performance computing in applied bioinformatics.
2	Understand and explain the role of HPC in large data driven operations.
3	Compare the difference in normal computing and HPC processing speed.
4	Develop basic scripts to run the commands in HPC

Unit-I	
Introduction to HPC Introduction to Linux operating system, Basic commands used in HPC cluster, Major components and its functions in HPC Cluster- head node, login node, interactive node, compute node, I/O node, Hardware architecture of HPC-processor design, cache architectures, design and evaluation techniques, operating systems and compilers, communications libraries, programming strategies for vector and parallel computers, optimization strategies, grid computing.	**07 Hrs**
Unit –II	
Introduction to shell scripting Basics of shell scripting,invocation, variables, if-then-else. Loops, Workflows and nested workflows, How to submit and monitor workflow execution. HPC Data Storage, Serial and parallel batch jobs and scripting to run processes in parallel.	**07 Hrs**
Unit –III	
Big Data analytics Introduction of Cloud computing, Hadoop architecture. MIKE2.0, Multiple layer architecture, Distributed Parallel architecture, NGS data analysis using Hadoop.	**07 Hrs**
Unit –IV	
Installation of Software Packages Install R packages, Perl modules, Python modules and general software packages. Molecular dynamics and use of VMD Software's and tools used to access HPC cluster with examples. Applications of High performance Computing in the field of Bioinformatics.	**07 Hrs**
Unit –V	
High throughput data analysis with HPC Conversion of SRA files, FASTQC analysis using HPC – Command and tools required, interpretation of results. Adapter trimming, Alignment, Variant calling, Performing BLAST search, interpretation of results. Comparison of the results from various tools using HPC.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Understand the basic knowledge of High Performance Computing
CO2:	Describe architectural hardware for high performance computing systems and installation of software packages
CO3:	Describe architectural hardware for high performance computing systems and installation of software packages
CO4:	Develop parallel software tools using High Performance Computing

Reference Books:	
1	Bioinformatics for High Throughput Sequencing, Naiara Rodríguez-Ezpeleta, Michael Hackenberg, Ana M. Aransay.| ISBN-13: 9781461407812
2	Next-generation DNA sequencing informatics, Stuart M. Brown 2013. Cold Spring Harbor Laboratory Press, Cold Spring Harbor: New York. ISBN-13: 978-1936113873

3	High-Throughput Next Generation Sequencing Methods and Applications Series, Young Min Kwon, Steven C. Ricke, ISBN: 978-1-61779-088-1 (Print) 978-1-61779-089-8
4	High Performance Computing, Kevin Autor Dowd, Michael KostaLoukides.O'Reilly& Associates, 1993.ISBN 1565920325, 9781565920323

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

Semester: II		
BUSINESSANALYTICS **(Global Elective)**		
Course Code:18 CSG01		**CIE Marks:100**
Credits: L:T:P: 3:0:0		**SEE Marks:100**
Hours: : 36L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Formulate and solve business problems to support managerial decision making.
2	Explore the concepts, processes needed to develop, report, and analyze business data.
3	Use data mining techniques, concepts to identify specific patterns in the data
4	Interpret data appropriately and solve problems from various sectors such as manufacturing, service, retail, software, banking and finance.

Unit-I	
Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling.	**07 Hrs**
Unit –II	
Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, Simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.	**07 Hrs**
Unit –III	
Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Change. Descriptive Analytics, Predictive Analytics, Predicative Modelling, Predictive analytics analysis.	**07 Hrs**
Unit –IV	
Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.	**08 Hrs**
Unit –V	
Decision Analysis: Formulating Decision Problems, Decision Strategies with and without Outcome, Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.	**07 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explore the concepts, data and models for Business Analytics.
CO2:	Analyze various techniques for modelling and prediction.
CO3:	Design the clear and actionable insights by translating data.
CO4:	Formulate decision problems to solve business applications.

Reference Books:	
1	Business analytics Principles, Concepts, and Applications, Marc J. Schniederjans, Dara G. Schniederjans, Christopher 2. Starkey, FT Press Analytics, 1st Edition, 2014, ISBN-13: 978-0133989403, ISBN-10: 0133989402
2	The Value of Business Analytics: Identifying the Path to Profitability, Evan Stubs , John Wiley & Sons, ISBN : 9781118983881 | DOI : 10.1002 / 9781118983881, 1st Edition 2014.
3	Business Analytics, James Evans, Pearsons Education 2nd edition, ISBN-13:978-

	0321997821ISBN-10:0321997824
4	Predictive Business Analytics Forward Looking Capabilities to Improve Business, Gary Cokins and Lawrence Maisel, , Wiley; 1st Edition, 2013.

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

Semester: II		
INDUSTRIAL & OCCUPATIONAL HEALTH AND SAFETY (Global Elective)		
Course Code:18CV2G02		**CIE Marks:100**
Credits: L:T:P: 3:0:0		**SEE Marks:100**
Hours: : 36L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Understand the Industrial and Occupational health and safety and its importance.
2	Understand the different materials, occupations to which the employee can be exposed to.
3	Know the characteristics of materials and effect on health.
4	Evaluate the different processes and maintenance required in the industries to avoid accidents.

Unit-I	
Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.	**07 Hrs**
Unit –II	
Occupational health and safety: Introduction, Occupational health: a definition, Interaction between work and health, Interaction between work and health, Health hazards, Unemployment, Health, workplace, economy and sustainable development, Work as a factor in health promotion. Health protection and promotion activities in the workplace: National governments, Management, Workers, Workers' representatives and unions, Communities, Occupational health professionals. Potential health hazards: Air contaminants, Chemical hazards, Biological hazards, Physical hazards, Ergonomic hazards, Psychosocial factors, Accident factors. Evaluation of health hazards: Exposure measurement techniques, Interpretation of findings recommended exposure limits. Controlling hazards: Engineering controls, Work practice controls, Administrative controls. Occupational diseases: Definition, Characteristics of occupational diseases, Prevention of occupational diseases.	**07 Hrs**
Unit –III	
HazardousMaterials characteristics and effects on health: Introduction, Chemical Agents, Organic Liquids: Introduction, Glycol Ethers (Cellosolve, Methyl Cellosolve, and Butyl Cellosolve) Esters: (Ethyl, Butyl, Amyl, and Cellosolve Acetates), Ketones (Acetone, Methyl Ethyl ketone, and Methyl Isobutyl Ketone), Aromatics (Toluene, Benzene, Xylene, Phenol, Styrene and Isocyanates), Polyaromatics (Chlorinated Compounds), Halogenated Hydrocarbons (Trichloroethylene, Trichloroethylene, Trichloroethane, Perchloroethylene, Methylene Chloride, Chloroform and Fluorocarbons), Alkyl Nitrites (Dimethylformamide), Aldehydes (Formaldehyde).Gases: Introduction, Boron (Boron Trichloride, Diborane and Boron Tribromide), Metal Hydrides (Arsine and Germane), Asphyxiants (Simple Asphyxiants, Carbon Monoxide and Cyanides), Silicon (Silane, Dichlorosilane, Trichlorosilane and Chlorosilane), Phosphine, Phosgene, Nitrogen Oxides and Ozone. Metals and Metallic Compounds: Introduction, Lead, Gallium, Indium and Antimony, Cadmium, Yttrium, Silver, Beryllium, Platinum, Gold, Tantalum, Mercury, Nickel, Arsenic, Tellurium, Tin, Barium, Cobalt. Particulates and Fibers: Introduction, Resin Dust, Fibrous Glass, Silica, Portland Cement, Mica. Acids, Alkalies and Oxidizers: Introduction, Sulfuric Acid, Chromium Acids, Hydrogen Fluoride (Hydrofluoric Acid), Sodium Hydroxide, Hydrogen Peroxide.General Manufacturing Materials: Epoxy Resin Systems, Flux Fumes, Cutting Fluids, Nonacid etches, Fluoride Compounds, Phosphorus Compounds, HexamethlyDisilazane, Chemical Combined Effects, Chemical Substitutes, Allergens, Carcinogens, Mutagens, Reproductive Hazards, Sensitizers and Teratogens, Recommended Chemical Exposure Limits. Physical Agents: Electromagnetic and particulate Radiation, Microwave and Radio Frequency Radiation, Particulate Radiation, Infrared Radiation, Laser Radiation, Ultraviolet Radiation, X-Radiation, Noise and Vibration, Temperature and	**08 Hrs**

Pressure, Carcinogenicity, Mutagenicity and Teratogenicity. Ergonomic Stresses: Stress-Related Health Incidents, Eyestrain, Repetitive Motion, Lower Back Pain, Video Display Terminals.	
Unit –IV	
Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.	**07 Hrs**
Unit –V	
Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.	**07 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explain the Industrial and Occupational health and safety and its importance.
CO2:	Demonstrate the exposure of different materials, occupational environment to which the employee can expose in the industries.
CO3:	Characterize the different type materials, with respect to safety and health hazards of it.
CO4:	Analyze the different processes with regards to safety and health and the maintenance required in the industries to avoid accidents.

Reference Books:	
1	Maintenance Engineering Handbook, Higgins & Morrow, SBN 10: 0070432015 / ISBN 13: 9780070432017, Published by McGraw-Hill Education. Da Information Services.
2	Maintenance Engineering, 3. P. Garg, S. Chand and Company, New Delhi, 2009.
3	WILL BE PROVIDED
4	Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

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

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Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
MODELING USING LINEAR PROGRAMMING (Global Elective)		
Course Code: 18IM2G03		**CIE Marks:100**
Credits: L:T:P: 3:0:0		**SEE Marks:100**
Hours: : 36L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Understand the concepts behind Linear Programming techniques.
2	Explain the modeling frameworks for solving problems using Linear Programming techniques.
3	Design and developLinear Programming models for real life situations.
4	Analyze solutions obtained using Linear Programming methods.

Unit-I	
Linear Programming: Introduction to Linear Programming problem **Simplex methods:** Variants of Simplex Algorithm – Use of Artificial Variables	**07 Hrs**
Unit –II	
Advanced Linear Programming : Two Phase simplex techniques, Revised simplex method **Duality:** Primal-Dual relationships, Economic interpretation of duality	**07 Hrs**
Unit –III	
Sensitivity Analysis: Graphical sensitivity analysis, Algebraic sensitivity analysis - changes in RHS, Changes in objectives, Post optimal analysis - changes affecting feasibility and optimality	**07 Hrs**
Unit –IV	
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.	**08 Hrs**
Unit –V	
Assignment Problem: Formulation of the Assignment problem, solution method of assignment problem-Hungarian Method, Variants in assignment problem, Travelling Salesman Problem (TSP).	**07 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Explain the various Linear Programming models and their areas of application.
CO2:	Formulate and solve problems using Linear Programming methods.
CO3:	Develop models for real life problems using Linear Programming techniques.
CO4:	Analyze solutions obtained through Linear Programming techniques.

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

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

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seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
PROJECT MANAGEMENT (Global Elective)		
Course Code: 18IM2G04		**CIE Marks:100**
Credits: L:T:P: 3:0:0		**SEE Marks:100**
Hours: : 36L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Understand the principles and components of project management.
2	Appreciate the integrated approach to managing projects.
3	Elaborate the processes of managing project cost and project procurements.
4	Use the project management tools and techniques.

Unit-I	
Introduction: Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS), Introduction to Agile Methodology.	**07 Hrs**
Unit –II	
Capital Budgeting: Capital Investments: Importance and Difficulties, phases of capital budgeting, levels of decision making, facets of project analysis, feasibility study – a schematic diagram, objectives of capital budgeting.	**07 Hrs**
Unit –III	
Project Costing: Cost of Project, Means of Finance, Cost of Production, Working Capital Requirement and its Financing, Profitability Projections, Projected Cash Flow Statement, Projected Balance Sheet, Multi-year Projections, Financial Modeling, Social Cost Benefit Analysis	**08 Hrs**
Unit –IV	
Tools & Techniques of Project Management: Bar (GANTT) chart, bar chart for combined activities, logic diagrams and networks, Project evaluation and review Techniques (PERT) Critical Path Method (CPM), Computerized project management.	**07 Hrs**
Unit –V	
Project Management and Certification: An introduction to SEI, CMMI and project management institute USA – importance of the same for the industry and practitioners. PMBOK 6 - Introduction to Agile Methodology, Themes / Epics / Stories, Implementing Agile. **Domain Specific Case Studies on Project Management:** Case studies covering project planning, scheduling, use of tools & techniques, performance measurement.	**07 Hrs**

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

Reference Books:	
1	Project Planning Analysis Selection Financing Implementation & Review, Prasanna Chandra, Tata McGraw Hill Publication, 8th Edition, 2010, ISBN 0-07-007793-2.
2	A Guide to the Project Management Body of Knowledge (PMBOK Guide), Project Management Institute, 5th Edition, 2013, ISBN: 978-1-935589-67-9
3	Project Management A System approach to Planning Scheduling & Controlling, Harold Kerzner, John Wiley & Sons Inc., 11th Edition, 2013, ISBN 978-1-118-02227-6.

4	Project Management – Planning and Controlling Techniques, Rory Burke, John Wiley & Sons, 4th Edition, 2004, ISBN: 9812-53-121-1

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

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Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
ENERGY MANAGEMENT (Global Elective)		
Course Code:18CH2G05		**CIE Marks:100**
Credits: L:T:P: 3:0:0		**SEE Marks:100**
Hours: : 36L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Acquire fundamental knowledge on Energy Management
2	Understand the concepts of biomass conversion to Energy
3	Asses the types of biomass energy conversion system
4	Learn alternate energy conversion systems

Unit-I	
Energy conservation: Principles of energy conservation and energy audit, types of energy audit, Energy conservation approaches, Cogeneration and types of cogeneration, Heat recuperators- classification, liquid/gas and gas/liquid heat exchangers.	**08 Hrs**
Unit –II	
Wet Biomass gasifiers: Introduction, Classification of feedstock for biogas generation. Biomass conversion technologies: Wet and dry processes, Photosynthesis, Biogas generation, Factors affecting bio-digestion, Classification of biogas plants, Floating drum plant and fixed dome plant their advantages and disadvantages, Biogas from aquatic weed.	**07 Hrs**
Unit –III	
Dry Biomass Gasifiers : Biomass energy conversion routes, Thermal gasification of biomass, Classification of gasifiers, Fixed bed systems: Construction and operation of up draught and down draught gasifiers and Pyrolysis.	**07 Hrs**
Unit –IV	
Solar Photovoltaic: Principle of photovoltaic conversion of solar energy, types of solar cells and fabrication. **Wind Energy:** Atmospheric circulations, classification, factors influencing wind, wind shear,turbulence, wind speed monitoring, Betz limit, WECS: classification, characteristics, and applications	**07 Hrs**
Unit –V	
Alternative liquid fuels: Introduction. Ethanol production: Raw materials, Pre-treatment, Conversion processes, Fermentation systems. Methanol production: Raw materials, Gasification of wood, Gas purification and shift conversion, Synthesis, Gasification equipment.	**07 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Understand the use alternate fuels for energy conversion
CO2:	Develop a scheme for energy audit
CO3:	Evaluate the factors affecting biomass energy conversion
CO4:	Design a biogas plant for wet and dry feed

Reference Books:	
1	Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2	Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3	Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
4	Solar Photovoltaics: Fundamental Applications and Technologies, C. S. Solanki, Prentice Hall of India, 2009, ISBN:9788120343863

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

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Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
INDUSTRIAL 4.0 (Global Elective)		
Course Code:18ME2G06		**CIE Marks:100**
Credits: L:T:P: 3:0:0		**SEE Marks:100**
Hours: : 36L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Understand the principles of digitization and enabling technologies of Industry 4.0
2	Demonstrate the technologies, protocols and tools for digitization of the industry
3	Apply the principles of digital transformation of a process and area / department in industries
4	Analyze the new strategic tools into business models
5	Adopt the components of digital transformation into the projects, the people and the teams that are involved

Unit-I	
Introduction: Industrial, Internet, Case studies, Cloud and Fog, M2M Learning and Artificial Intelligence, AR, Industrial Internet Architecture Framework (IIAF), Data Management.	**07 Hrs**
Unit –II	
The Concept of the IIoT: Modern Communication Protocols, Wireless Communication Technologies, Proximity Network Communication Protocols, TCP/IP, API: A Technical Perspective, Middleware Architecture, Industry 4.0, Characteristics of Industry 4.0, The Value Chain, Industry 4.0 Design Principles.	**07 Hrs**
Unit –III	
Data Analytics in Manufacturing: Introduction, Power Consumption in manufacturing, Anomaly Detection in Air Conditioning, Smart Remote Machinery Maintenance Systems with Komatsu, Quality Prediction in Steel Manufacturing, Predicting Drilling Efficiency, Estimation of Manufacturing Cost of Jet Engine, Components, Techniques Used for Predictive Analytics, Forecast Accuracy Calculation Internet of Things and New Value Proposition, Introduction, Internet of Things Examples, IoTs Value Creation Barriers: Standards, Security and Privacy Concerns. Advances in Robotics in the Era of Industry 4.0, Introduction, Recent Technological Components of Robots, Advanced Sensor Technologies, Artificial Intelligence, Internet of Robotic Things, Cloud Robotics, Cognitive Architecture for Cyber-Physical Robotics, Industrial Robotic Applications.	**08 Hrs**
Unit –IV	
Additive Manufacturing Technologies and Applications: Introduction, Additive Manufacturing (AM) Technologies, Stereo lithography, 3DP, Fused Deposition Modeling, Selective Laser Sintering, Laminated Object Manufacturing, Laser Engineered Net Shaping, Advantages of Additive Manufacturing, Disadvantages of Additive Manufacturing, Application Areas of Additive Manufacturing, Impact of Additive Manufacturing Techniques on Society Advances in Virtual Factory Research and Applications, The State of Art, The Virtual Factory Software , Limitations of the Commercial Software	**07 Hrs**
Unit –V	
Augmented Reality: The Role of Augmented Reality in the Age of Industry 4.0, Introduction, AR Hardware and Software Technology, Industrial Applications of AR, Maintenance , Assembly, Collaborative Operations , Training. Smart Factories: Introduction, Smart factories in action, Importance, Real world smart factories, The way forward. A Roadmap: Digital Transformation, Transforming Operational Processes, Business Models, Increase Operational Efficiency, Develop New Business Models.	**07 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Understand the opportunities, challenges brought about by Industry 4.0 for benefits of organizations and individuals
CO2:	Analyze the effectiveness of Smart Factories, Smart cities, Smart products and Smart services
CO3:	Apply the Industrial 4.0 concepts in a manufacturing plant improve productivity and profits
CO4:	Evaluate the effectiveness of Cloud Computing in a networked economy

Reference Books:	
1	Industry 4.0 the industrial internet of things, Alasdair Gilchrist Apress Publisher, ISBN-13 : 978-1-4842-2046-7
2	Industry 4.0: Managing The Digital Transformation, Alp Ustundag • EmreCevikcan Springer, 2018 ISBN 978-3-319-57869-9
3	Designing the industry - Internet of things connecting the physical, digital and virtual worlds, OvidiuVermesan and Peer Friess Rivers Publishers, 2016 ISBN 978-87-93379-81-7
4	ONE MORE REQUIRED

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

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
ADVANCED MATERIALS (Global Elective)		
Course Code:18ME2G07		**CIE Marks:100**
Credits: L:T:P: 3:0:0		**SEE Marks:100**
Hours: : 36L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Classify and Select engineering materials for various applications
2	Describe different non-metallic engineering materials with respect to properties and applications– Plastics, Ceramics, Optical fibres, Composites
3	Explain the properties and applications of high strength materials
4	Describe different materials for low and high temperature applications.
5	Explain physical and mechanical properties and applications of nanomaterials

Unit-I	
Classification and Selection of Materials: Classification of materials. The properties required in Engineering materials, Criteria of selection of materials.Requirements / needs of advance materials.	**07 Hrs**
Unit –II	
Non Metallic Materials: Classification of on metallic materials, Rubber : Properties, processing and applications.Plastics : Thermosetting and Thermoplastics, Applications and properties. Ceramics : Properties and applications. Adhesives: Properties and applications. Optical fibers : Properties and applications. Composites : Properties and applications.	**07 Hrs**
Unit –III	
High Strength Materials: Methods of strengthening of alloys, Materials available for high strength applications, Properties required for high strength materials, Applications of high strength materials	**08 Hrs**
Unit –IV	
Low & High Temperature Materials The properties required for low temperature applications, Materials available for low temperature applications, Requirements of materials for high temperature applications, Materials available for high temperature applications, Applications of low and high temperature materials.	**07 Hrs**
Unit –V	
Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials.	**07 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Describe metallic and nonmetallic materials
CO2:	Explain preparation of high strength Materials
CO3:	Integrate knowledge of different types of advanced engineering Materials
CO4:	Analyse problem and find appropriate solution for use of materials.

Reference Books:	
1	The Science & Engineering of Materials, Donald R. Askeland, and Pradeep P. Fulay, 5th Edition, Thomson, 2006, ISBN-13-978-0534553968
2	Nanotechnology,Gregory 1. Timp, 1999th EditionmmSpringer, 1999 ISBN-13: 978-0387983349
3	**Material Science and Metallurgy, Dr. VD Kodgire and Dr. S V Kodgire, 42nd Edition 2018, Everest Publishing House ISBN NO: 81 86314 00 8**
4	Processing and Fabrication of Advanced Materials, N Bhatnagar, T S Srivatsan, 2008, IK International, ISBN: 978819077702

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

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
COMPOSITE MATERIALS SCIENCE AND ENGINEERING (Common to AS, BT, CH, CV, IM, ME)		
Course Code: 18CHY2G08		**CIE Marks: 100**
Credits: L:T:P:S: 3:1:0:0		**SEE Marks: 100**
Hours: 36L +12T		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Understand the properties of composite materials.
2	Apply the basic concepts of Chemistry to develop futuristic composite materials for high-tech applications in the area of Engineering.
3	Impart knowledge in the different fields of material chemistry so as to apply it to the problems in engineering field.
4	Develop analytical capabilities of students so that they can characterize, transform and use materials in engineering and apply knowledge gained in solving related engineering problems.

Unit-I	
Introduction to composite materials Fundamentals of composites – need for composites – Enhancement of properties – Classification based on matrix- Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) – Constituents of composites, Interfaces and Interphases, Distribution of constituents, Types of Reinforcements, Particle reinforced composites, Fibre reinforced composites. Fiber production techniques for glass, carbon and ceramic fibers Applications of various types of composites.	**07 Hrs**
Unit – II	
Polymer matrix composites (PMC) Polymer resins – Thermosetting resins, Thermoplastic resins & Elastomers, Reinforcement fibres-Types, Rovings, Woven fabrics. PMC processes – Hand Layup Processes, Spray up processes – Compression Moulding – Injection Moulding – Resin Transfer Moulding – Pultrusion – Filament winding – Injection moulding. Glass fibre and carbon fibre reinforced composites (GFRP & CFRP). Laminates- Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Mechanical Testing of PMC- Tensile Strength, Flexural Strength, ILSS, Impact Strength- As per ASTM Standard. Applications of PMC in aerospace, automotive industries**.**	**08 Hrs**
Unit -III	
Ceramic matrix composites and special composites Engineering ceramic materials – properties – advantages – limitations – monolithic ceramics – need for CMC – ceramic matrix – various types of ceramic matrix composites- oxide ceramics – non oxide ceramics – Aluminium oxide – silicon nitride – reinforcements – particles- fibres- whiskers. Sintering – Hot pressing – Cold Isostatic Pressing (CIPing) – Hot isostatic pressing (HIPing). Applications of CMC in aerospace, automotive industries- Carbon /carbon composites – advantages of carbon matrix – limitations of carbon matrix carbon fibre – chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique- Processing of Ceramic Matrix composites.	**07 Hrs**
Unit –IV	
Metal matrix composites	**07**

Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Reinforcements – particles – fibres. Effect of reinforcement – volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process – diffusion bonding – stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface-measurement of interface properties- applications of MMC in aerospace, automotive industries.	**Hrs**
Unit –V	
Polymer nano composites Introduction and Significance of polymer Nano composites. Intercalated And Exfoliated Nanocomposites. Classification of Nano fillers- nanolayers, nanotubes, nanoparticles. Preparation of Polymer Nano composites by Solution, In-situ Polymerization and melt mixing techniques. Characterization Of polymer nanocomposites- XRD, TEM, SEM and AFM. Mechanical and Rheological properties of Polymer Nano composites. Gas barrier, Chemical-Resistance, Thermal and Flame retardant properties of polymer nanocomposites. Optical properties and Biodegradability studies of Polymer nanocomposites, Applications of polymer nano-composites.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the purpose and the ways to develop new materials upon proper combination of known materials.
CO2:	Identify the basic constituents of a composite materials and list the choice of materials available
CO3:	Will be capable of comparing/evaluating the relative merits of using alternatives for important engineering and other applications.
CO4:	Get insight to the possibility of replacing the existing macro materials with nano-materials.

Reference Books	
1	Composite Materials Science and Engineering, Krishan K Chawla, 3rd Edition Springer-verlag Gmbh, , ISBN: 9780387743646, 0387743642
2	The Science and Engineering of Materials, K Balani, Donald R Askeland,6th Edition-Cengage, Publishers, ISBN: 9788131516416
3	Polymer Science and Technology, Joel R Fried , 2nd Edition, Prentice Hall, ISBN: 9780137039555
4	Nanomaterials and nanocomposites, Rajendra Kumar Goyal , 2nd Edition, CRC Press-Taylor & Francis, ISBN: 9781498761666, 1498761666

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

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Total CIE is 20+50+30=100 Marks.

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

Semester: II		
Physics of Materials (Global Elective)		
Course Code:18PH2G09		**CIE Marks:100**
Credits: L:T:P: 3:0:0		**SEE Marks:100**
Hours: : 36L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Classify the crystals based on lattice paramters.
2	Explain the behavior of Dielectrics with change in frequency.
3	Classify the magnetic materials based on Quantum theory as well understand superconductors.
4	Explain direct and indirect band gap semiconductors, polymer semiconductors and Photoconductive polymers.
5	Describe the behavior of Smart materials and its phases.

Unit-I	
Crystal Structure Symmetry elements-seven crystals systems-Reciprocal lattice-Packing fraction, Lattice Vibration-Brillouin zones, Analysis of Crystal structure using XRD, Thermal properties.	**07 Hrs**
Unit –II	
Dielectric Materials Basic concepts-Langevin's Theory of Polarisation-Clausius-Mossotti Relation-Ferro electricity-Piezoelectricity-Properties of Dielectric in alternating fields-The complex Dielectric Constant and Dielectric Loss, Polarizability as a function of frequency-Complex dielectric constant of non-polar solids-Dipolar relaxation, Applications.	**07 Hrs**
Unit –III	
Magnetic Materials Dia and Paramagnetic materials-Quantum theory of paramagnetic materials-Paramagnetic susceptibility of conduction electrons-Ferro-anti ferromagnetic materials-Superconductors and Applications.	**07 Hrs**
Unit –IV	
Semiconducting Materials Semiconductor-Direct and Indirect bonding characteristics-Importance of Quantum confinement-quantum wires and dots-Ferro electric semiconductors-applications-Polymer semiconductors-Photo conductive polymers, Applications.	**07 Hrs**
Unit –V	
Novel Materials Smart materials-shape memory alloys-shape memory effects-Martensitia Transformation functional properties-processing-texture and its nature.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Analyse crystals using XRD technique.
CO2:	Explain Dielectric and magnetic materials.
CO3:	Integrate knowledge of various types of advanced engineering Materials.
CO4:	Use materials for novel applications.

Reference Books:	
1	Solid State Physics, S O Pillai, 2015, New Age International Publishers, ISBN 10-8122436978.
2	Introduction to Solid State Physics, C.Kittel, Seventh Edition, 2003, John Wiley & Sons, ISBN 9971-51-180.
3	Material Science, Rajendran V and Marikani, , Tata McGraw Hill, 2013, ISBN 10-007132871.
4	The Science and Engineering of Materials, Askeland, Fulay, Wright, Balanai, Sixth Edition, 2012 Cengage Learning, ISBN-13:978-0-495-66802-2.

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

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Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
Advanced Statistical Methods (Global Elective)		
Course Code:18MT2G10		**CIE Marks:100**
Credits: L:T:P: 3:0:0		**SEE Marks:100**
Hours: : 36L		**SEE Duration:3Hrs**

Course Learning Objectives:	
1	Adequate exposure to learn sampling techniques, random phenomena for analyzing data for solving real world problems.
2	To learn fundamentals of estimation and problems used in various fields of engineering and science.
3	Explore the fundamental principles of statistical inference and tests of hypothesis.
4	Apply the concepts of regression and statistical models to solve the problems of engineering applications.

Unit-I	
Sampling Techniques: Random numbers, Concepts of random sampling from finite and infinite populations, Simple random sampling (with replacement and without replacement). Expectation and standard error of sample mean and proportion.	**07 Hrs**
Unit –II	
Estimation: Point estimation, Estimator and estimate, Criteria for good estimates - unbiasedness, consistency, efficiency and sufficiency, Method of moment's estimation and maximum likelihood estimation, Properties of maximum likelihood estimator (no proofs), Confidence intervals-population mean (large sample), population proportion.	**07 Hrs**
Unit –III	
Tests of Hypothesis: Principles of Statistical Inference, Formulation of the problems with examples, Simple and composite hypothesis, Null and alternative hypothesis, Tests - type I and type II error, Testing of mean and variance of normal population (one sample and two samples), Chi squared test for goodness of fit.	**07 Hrs**
Unit –IV	
Linear Statistical Models: Definition of linear model and types, One way ANOVA and two way ANOVA models-one observation per cell, multiple but equal number of observation per cell.	**07 Hrs**
Unit –V	
Linear Regression: Simple linear regression, Estimation of parameters, Properties of least square estimators, Estimation of error variance, Multivariate data, Multiple linear regressions, Multiple and partial correlation, Autocorrelation-introduction and plausibility of serial dependence, sources of autocorrelation, Durbin-Watson test for auto correlated variables.	**08 Hrs**

Expected Course Outcomes:After going through this course the student will be able to	
CO1:	Identify and interpret the fundamental concepts of sampling techniques, estimates and types, hypothesis, linear statistical models and linear regression arising in various fields engineering.
CO2:	Apply the knowledge and skills of simple random sampling, estimation, null and alternative hypotheses, errors, one way ANOVA, linear and multiple linear regressions.
CO3:	Analyze the physical problem to establish statistical/mathematical model and use appropriate statistical methods to solve and optimize the solution.
CO4:	Distinguish the overall mathematical knowledge gained to demonstrate the problems of

	sampling techniques, estimation, tests of hypothesis, regression and statistical model arising in many practical situations.

Reference Books:	
1	Fundamentals of Statistics (Vol. I and Vol. II), M. Goon, M. K. Gupta and B. Dasgupta- World Press Private Limited, 3rd Edition, 1968, ISBN-13: 978-8187567806.
2	Applied Statistics and Probability for Engineers, C. Montgomery and G. C. Runger, John Wiley & Sons, Inc., 3rd Edition, 2003, ISBN 0-471-20454-4.
3	Fundamentals of Mathematical Statistic - A Modern Approach, S.C. Gupta, V.K. Kapoor, S Chand Publications, 10th Edition, 2000, ISBN 81-7014-791-3.
4	Regression Analysis: Concepts and Applications – F. A. Graybill and H. K. Iyer, Belmont, Calif.: Duxbury Press, 1994, ISBN-13: 978-0534198695.

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

MINOR PROJECT				
Course Code: 18MBT24		**CIE Marks**	**:**	**100**
Credits: L:T:P: 0:0:10		**SEE Marks**	**:**	**100**
Hours: :		**SEE Duration**	**:**	**3 Hrs**

Course Learning Objectives (CLO):

1	Create interest in innovative development.
2	Apply engineering knowledge to practical problems
3	Inculcate the skills for good presentation and technical report writing skills.
4	Apply management principles while executing the project

GUIDELINES

1. Each project group will consist of maximum of two students.
2. Each student / group has to select a contemporary topic that will use the technical knowledge of their program of study after intensive literature survey.
3. Allocation of the guides preferably in accordance with the expertise of the faculty.
4. The number of projects that a faculty can guide would be limited to four.
5. The minor project would be performed in-house.
6. The implementation of the project must be preferably carried out using the resources available in the department/college.

Course Outcomes:

After going through this course the students will be able to

CO1: Conceptualize, design and implement solutions for specific problems.
CO2: Communicate the solutions through presentations and technical reports.
CO3: Apply resource managements skills for projects
CO4: Synthesize self-learning, team work and ethics.

Scheme of Continuous Internal Examination (CIE)

Evaluation will be carried out in THREE Phases. The evaluation committee will comprise of FOUR members: guide, two senior faculty members and Head of the Department.

Phase	Activity	Weightage
I	Synopsis submission, Preliminary seminar for the approval of selected topic and Objectives formulation	20%
II	Mid-term seminar to review the progress of the work and documentation	40%
III	Oral presentation, demonstration and submission of project report	40%

****Phasewise rubrics to be prepared by the respective departments**

Scheme of Continuous Internal Examination (CIE)

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****Phase wise rubrics to be prepared by the respective departments**

CIE Evaluation shall be done with weightage / distribution as follows:

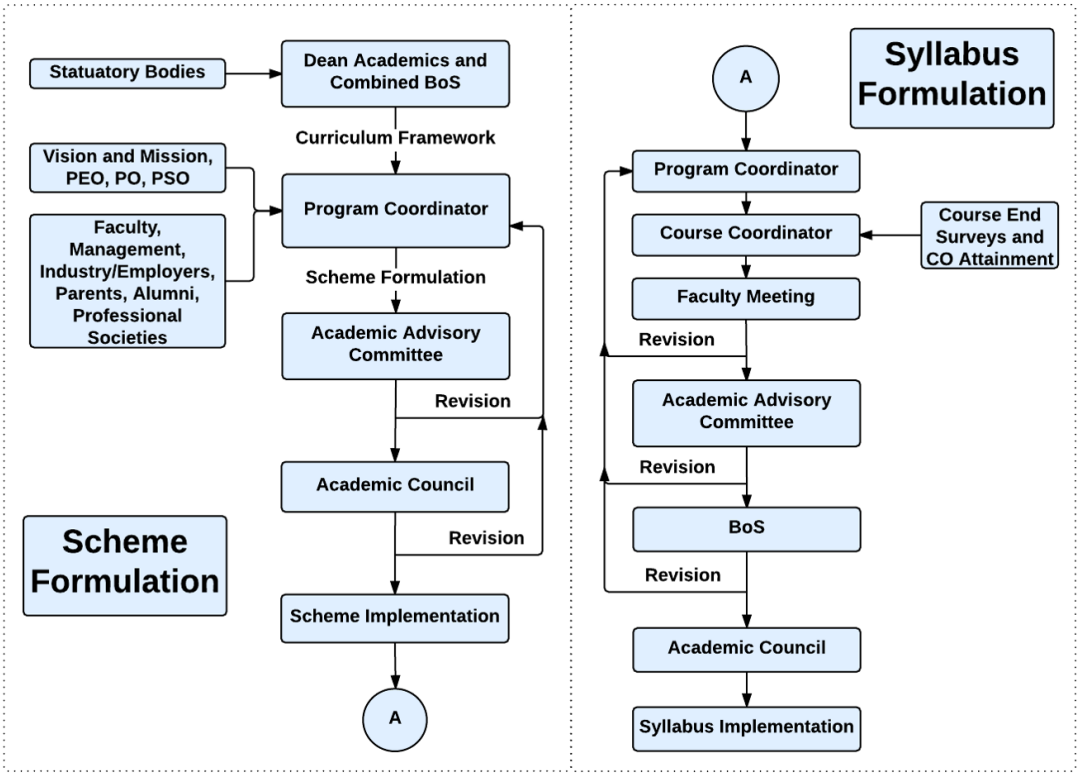
- Selection of the topic & formulation of objectives 10%
- Design and simulation/ algorithm development/experimental setup 25%
- Conducting experiments / implementation / testing 25%
- Demonstration & Presentation 15%
- Report writing 25%

Scheme for Semester End Evaluation (SEE):

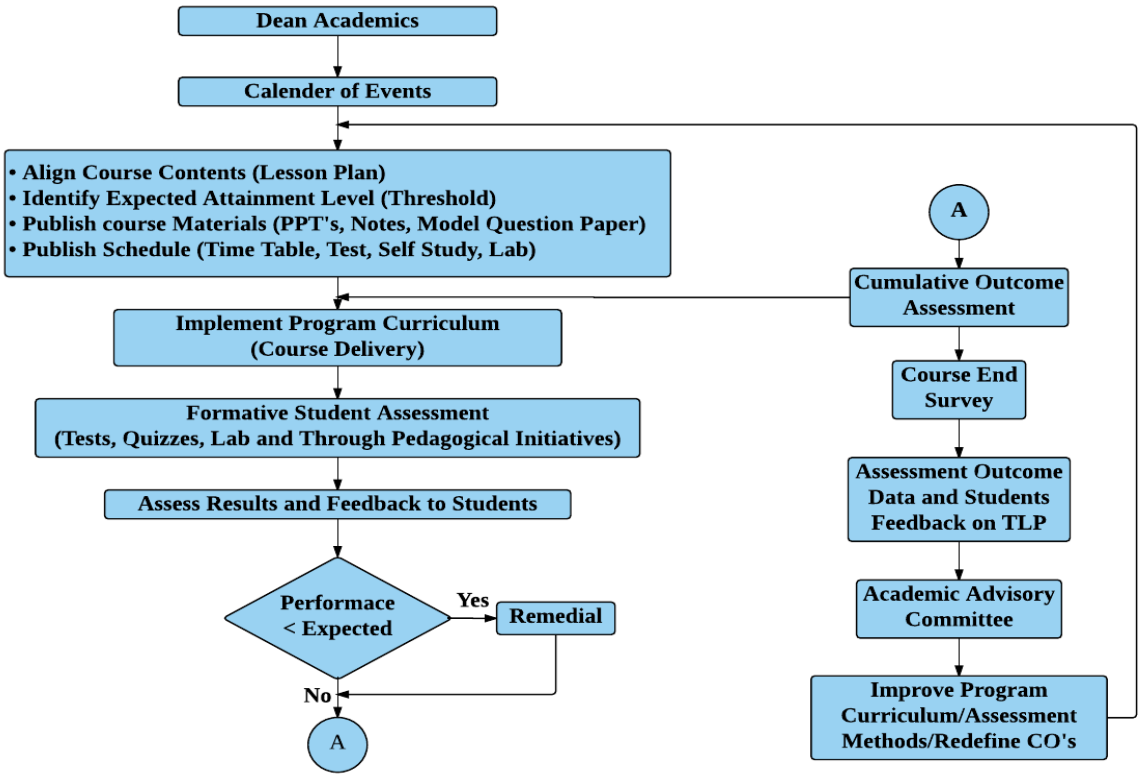
The evaluation will be done by ONE senior faculty from the department and ONE external faculty member from Academia / Industry / Research Organization. The following weightages would be given for the examination. Evaluation will be done in batches, not exceeding 6 students.

1. Brief write-up about the project 5%
2. Presentation / Demonstration of the project 20%
3. Methodology and Experimental Results & Discussion 25%
4. Report 20%
5. Viva Voce 30%

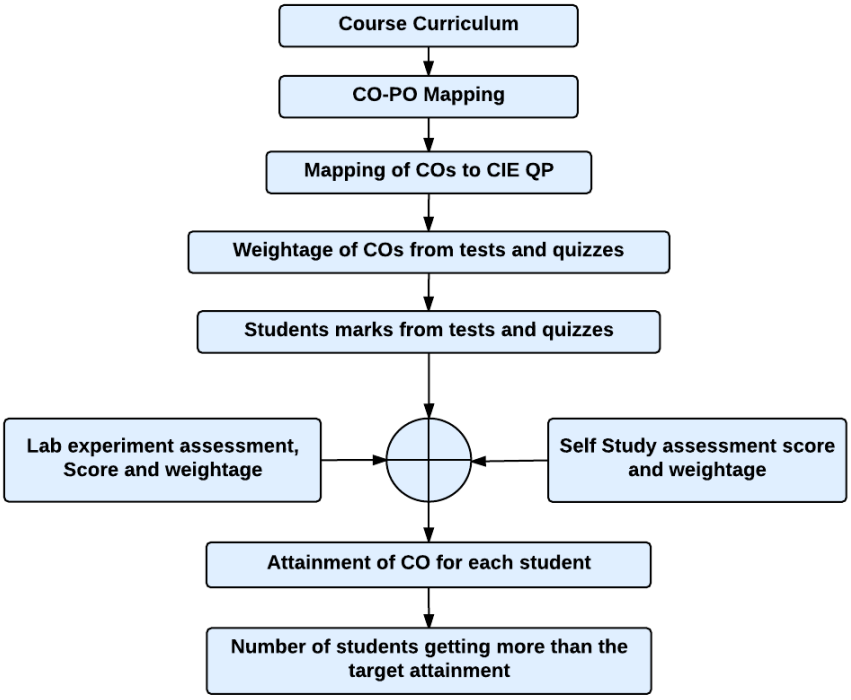
Curriculum Design Process



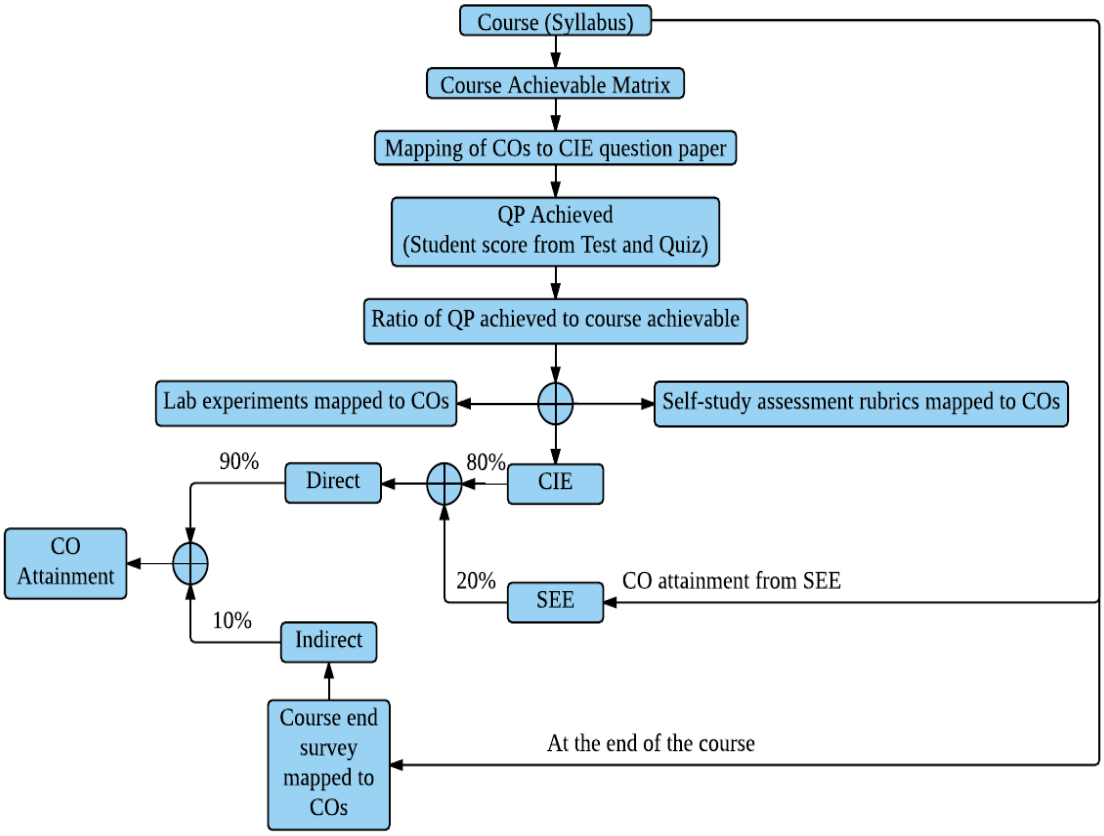
Academic Planning And Implementation



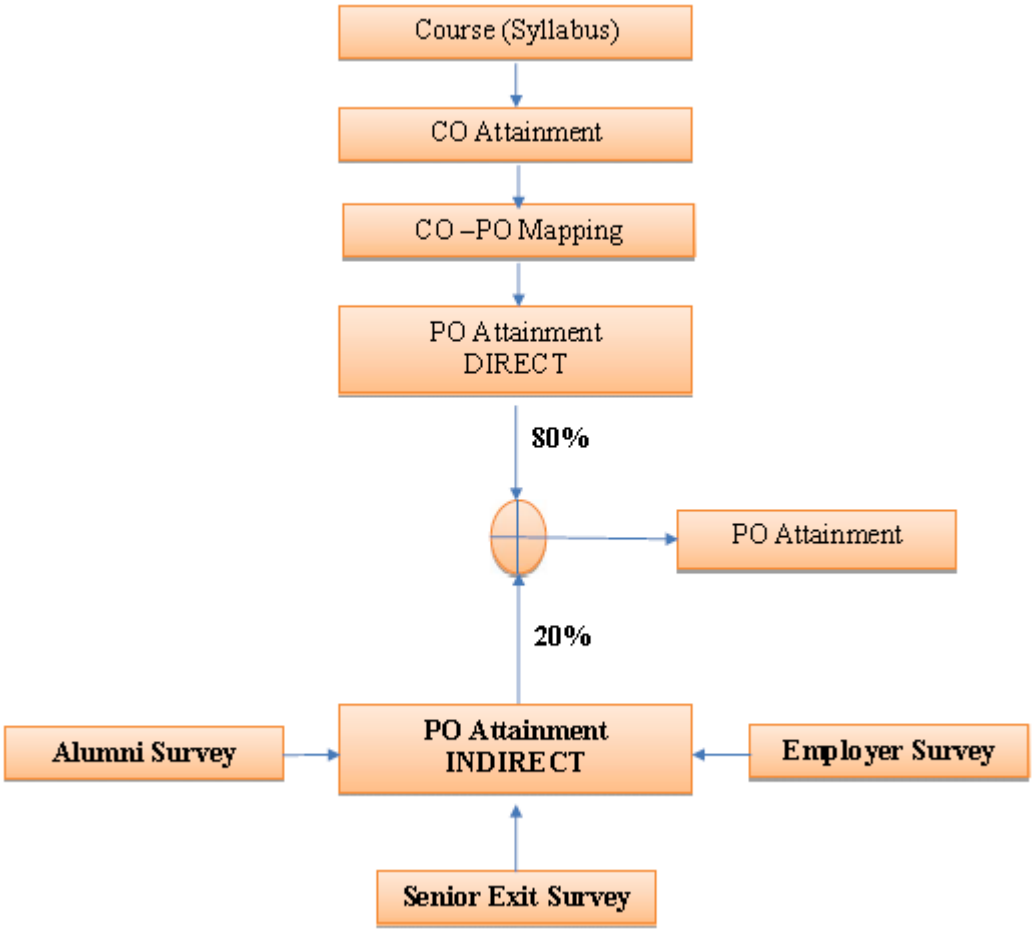
Process For Course Outcome Attainment



Final CO Attainment Process



Program Outcome Attainment Process



PROGRAM OUTCOMES (PO)

Graduates of M. Tech. in Biotechnology will be able to:

PO 1. Independently carry out research/investigation and development work to solve problems related to biotechnological sector.

PO 2. Write and present a substantial technical report/document in the fields of health, pharma, bioprocess, food and Agriculture.

PO 3. Apply advanced tools and techniques to design and formulate the solutions for various biotechnological challenges.

PO 4. Collaborate with the confluence of various domains of Biotech from academic, industry and research institutes of national or international repute, with the commitment to lifelong learning.

PO 5. Design and develop projects related to biotechnological and allied branches keeping performance and cost constraints into consideration.

PO 6. Apply bio-engineering solutions to societal and ethical needs with focus on sustainability.