RV COLLEGE OF ENGINEERING®

(Autonomous Institution Affiliated to VTU, Belagavi)
RV Vidyaniketan Post, Mysore Road
Bengaluru – 560059

Scheme and Syllabus of I to IV Semester

(Autonomous System of 2018 Scheme)

Master of Technology (M.Tech)
in
BIOTECHNOLOGY

DEPARTMENT OF
BIOTECHNOLOGY

DEPARTMENT OF
BIOTECHNOLOGY

VISION

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

MISSION

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

QUALITY POLICY

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

CORE VALUES

Professionalism, Commitment, Integrity, Team Work and Innovation

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Master of Technology (M.Tech)
in
BIOTECHNOLOGY

DEPARTMENT OF
BIOTECHNOLOGY

VISION

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

MISSION

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

PROGRAMME OUTCOMES (PO)

M.Tech in Biotechnology graduates will be able to:

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

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

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

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

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

PO6: Apply bio-engineering solutions to societal and ethical needs with focus on sustainability

ABBREVIATIONS

Sl. No.	Abbreviation	Acronym
1.	VTU	Visvesvaraya Technological University
2.	BS	Basic Sciences
3.	CIE	Continuous Internal Evaluation
4.	SEE	Semester End Examination
5.	CE	Professional 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.	PY	Physics
21.	CY	Chemistry
22.	MA	Mathematics
23.	MCA	Master of Computer Applications
24.	MST	Structural Engineering
25.	MHT	Highway Technology
26.	MPD	Product Design & Manufacturing
27.	MCM	Computer Integrated & Manufacturing
28.	MMD	Machine Design
29.	MPE	Power Electronics
30.	MVE	VlSI Design & Embedded Systems
31.	MCS	Communication Systems
32.	MBS	Bio Medical Processing Signal &Instrumentation
33.	MCH	Chemical Engineering
34.	MCE	Computer Science & Engineering
35.	MCN	Computer Network Engineering
36.	MDC	Digital Communication
37.	MRM	Radio Frequency and Microwave Engineering
38.	MSE	Software Engineering
39.	MIT	Information Technology
40.	MBT	Biotechnology
41.	MBI	Bioinformatics

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DEPARTMENT OF BIOTECHNOLOGY

M.Tech in BIOTECHNOLOGY

CONTENTS

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				**18**	**4**	**4**	**26**

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				**20**	**4**	**6**	**30**

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

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

THIRD SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Credits**
1	18MBT31	Downstream Process Technology	BT	4	0	1	**5**
2	18MBT32	Internship	BT	0	0	5	**5**
3	18MBT33	Major project Phase I	BT	0	0	5	**5**
4	18MBT3EX	Elective -E	BT	4	0	0	**4**
Total number of Credits				**8**	**0**	**11**	**19**
Total Number of Hours/Week				**8**	**0**	**22**	**30**

SEMESTER: III		
GROUP E: PROFESSIONAL ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1	18MBT3E1	Nanobiotechnology
2	18MBT3E2	Biobusiness, Project Management and Economics
3	18MBT3E3	Next Generation Sequencing Technology

FOURTH SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Credits**
1	18MBT41	Major Project Phase II	BT	0	0	20	**20**
2	18MBT42	Technical Seminar	BT	0	0	2	**2**
Total number of Credits				**0**	**0**	**22**	**22**
Total Number of Hours / Week				**0**	**0**	**44**	**44**

SEMESTER: I						
APPLIED MATHEMATICS **(Theory)** **(Common to MPE, MBT, MBI, MCH, MST, MHT, MPD, MMD, MCM)**						
Course Code	**:**	**18MAT11A**		**CIE Marks**	**:**	**100**
Credits: L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**3Hrs**

Unit-I	**10 Hrs**
Statistics: Method of least squares, fitting of straight line, linearization of nonlinear laws, curve fitting by polynomials, correlation, coefficient of correlation, lines of regression, Spearman rank correlation.	
Unit –II	**10 Hrs**
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.	
Unit –III	**10 Hrs**
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.	
Unit –IV	**11 Hrs**
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	
Unit –V	**11 Hrs**
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.	

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.

CO4: Analyze the physical problem to establish statistical/mathematical model and use appropriate method to solve and optimize the solution.

CO1: 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	**:**	**18MBT12**		**CIE Marks**	:	**100+50**
Credits: L:T:P	**:**	**4:0:1**		**SEE Marks**	:	**100+50**
Hours	**:**	**52L**		**SEE Duration**	:	**3Hrs**

Unit-I	**10 Hrs**

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.

Unit –II	**11 Hrs**

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,

Unit –III	**10 Hrs**

Components of rDNA technology: Isolation and purification of DNA (genomic and plasmid) and RNA. Chemical synthesis of DNA: Phosphoramidite method, use of synthesized oligonucleotides. Labelling nucleic acids: Radioactive and non-radioactive, end 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.

Unit –IV	**10 Hrs**

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. Analysis of cloned genes: Characterization based on mRNA translation in vitro, Restriction mapping, Blotting techniques, DNA sequencing.

Unit –V	**11 Hrs**

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.

Unit-VI (Practical component)	26 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)	

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); 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.**

Continuous Internal Evaluation (CIE); Practical (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.

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

SEMESTER: I						
COMPUTATIONAL GENOMICS AND PROTEOMICS (Theory and Practice)						
Course Code	**:**	**18MBT13**		**CIE Marks**	**:**	**100+50**
Credits: L:T:P	**:**	**4:0:1**		**SEE Marks**	**:**	**100+50**
Hours	**:**	**52L**		**SEE Duration**	**:**	**3Hrs**

Unit-I	**11 Hrs**

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.

Unit –II	**11 Hrs**

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.

Unit –III	**11 Hrs**

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.

Unit –IV	**10 Hrs**

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.

Unit –V	**09 Hrs**

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.

Unit-VI (Practical component)	**26 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.

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

1	Systems Biology for Signaling Networks, Choi. S, Publisher-Springer, New York,2010. ISBN 978-1-4419-5796-2
2	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.

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

SEMESTER: I						
STEM CELLS AND TISSUE ENGINEERING (Professional Elective-A1)						
Course Code	:	**18MBT1A1**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**
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.	
Unit –II	**08 Hrs**
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.	
Unit –III	**08 Hrs**
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.	
Unit –IV	**08 Hrs**
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.	
Unit –V	**07 Hrs**
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.	

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.

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. 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) Minor project.
Total CIE (Q+T+A) 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 (Professional Elective-A2)						
Course Code	:	**18MBT1A2**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**

Concepts and scope of Agricultural Biotechnology: Tissue culture in crop improvement, Micropropagation. Meristem culture and production of virus-free plants. Haploids in plant breeding; Anther, 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.

Unit –II	**08 Hrs**

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.

Unit –III	**07 Hrs**

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.

Unit –IV	**08 Hrs**

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.

Unit –V	**08 Hrs**

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

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.

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. 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) Minor project.

Total CIE (Q+T+A) 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 (Professional Elective-A3)						
Course Code	:	**18MBT1A3**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**
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.	
Unit –II	**08 Hrs**
Shell programming: Introduction to Shell scripting/programming, Variables, Special Variables, Operators, Arrays, and Statements.	
Unit –III	**08 Hrs**
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.	
Unit –IV	**07 Hrs**
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.	
Unit –V	**08 Hrs**
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.	

Course Outcomes

After going through this course the student will be able to

CO1: Explainand 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.

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. 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) Minor project.

Total CIE (Q+T+A) 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 (Professional Elective-B1)						
Course Code	:	**18MBT1B1**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**

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.

Unit –II	**08 Hrs**

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.

Unit –III	**08 Hrs**

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.

Unit –IV	**07 Hrs**

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.

Unit –V	**08 Hrs**

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.

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.

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. 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) Minor project.
Total CIE (Q+T+A) 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 (Professional Elective-B2)						
Course Code	:	**18MBT1B2**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**
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.	
Unit –II	**08 Hrs**
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.	
Unit –III	**08 Hrs**
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.	
Unit –IV	**07 Hrs**
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.	
Unit –V	**08 Hrs**
. **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.	

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	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

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. 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) Minor project.
Total CIE (Q+T+A) 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 (Professional Elective-B3)						
Course Code	:	**18MBT1B3**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**
Introduction to Systems Biology: Scope, Applications. Concepts, implementation and application. Databases for Systems Biology, Mass Spectrometry and systems Biology	
Unit –II	**07 Hrs**
Modeling Tools: SBML, MathML, CellML, Petri Nets and Bioinformatics.	
Unit –III	**08 Hrs**
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.	
Unit –IV	**08 Hrs**
Integrated Regulatory and Metabolic Models - Phosphorylation, Gene expression, and Metabolites. Estimation Modeling and Simulation - Circadian rhythms, Petri net, mRNA. Deterministic - Circadian rhythms, mRNA, Circadian oscillations. Multi scale representations of Cells and Emerging Phenotypes - Gene Regulatory Networks, attractor, and Boolean functions. Mathematical models and Optimization methods for De Novo Protein design. Global Gene expression assays. Mapping Genotype - Phenotype relationship in cellular networks.	
Unit –V	**08 Hrs**
Multiscale representations of cells and Emerging phenotypes: Multistability and Multicellurarity, Spatio-Temporal systems biology, Cytomics – from cell state to predictive medicine.	

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

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. 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) Minor project.
Total CIE (Q+T+A) 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**
CreditsL: T: P	**:**	**0:0:0**		**SEE Marks**	**:**	**Audit Course**
Hours	**:**	**24 L**				

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	**03 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

Phase	Activity
I	After the completion of Unit 1 and Unit 2, 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	Students will have to take up second test after the completion Unit 3, Unit 4 and Unit 5.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%.The attendance will be same as other courses.

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

SEMESTER: II						
UPSTREAM PROCESS TECHNOLOGY (Theory and Practice)						
Course Code	**:**	**18MBT21**		**CIE Marks**	:	**100+50**
Credits: L:T:P	**:**	**4:0:1**		**SEE Marks**	:	**100+50**
Hours	**:**	**52L**		**SEE Duration**	:	**3Hrs**

Unit-I	**10 Hrs**

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.

Unit –II	**11 Hrs**

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).

Unit –III	**10 Hrs**

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.

Unit –IV	**11 Hrs**

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).

Unit –V	**10 Hrs**

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 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)	**26 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.
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); 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.**

Continuous Internal Evaluation (CIE); Practical (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.

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

SEMESTER: II						
PHARMACEUTICAL TECHNOLOGY						
Course Code	:	**18MBT22**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**4:0:0**		**SEE Marks**	:	**100**
Hours:	:	**52L**		**SEE Duration**	:	**3Hrs**

Unit-I	**10 Hrs**

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

Unit –II	**10 Hrs**

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

Unit –III	**10 Hrs**

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.

Unit –IV	**11 Hrs**

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

Immuno-Therapeutics: Development of immuno-drugs. Cytokines classification, pathways of activation, Therapeutic use of cytokines. Immunomodulators classification, thymic hormones and synthetic immunostimulators. Compliment pathways diagnostics, ELISA, Flow cytometry, ELISPOT, immuno radiology, Basic immunotoxicology - Principles of testing of immunomodurating drugs and Xenobiotics

Unit –V	**11 Hrs**

Drug Pharmacology: Chemical transmission and drug action in the CNS. Diuretics, Drugs altering the pH of urine, excretion of organic molecules.Molecular Cardiology: Congenital Heart Disease, Inherited Cardiomyopathies, Coronary Atherosclerosis, Derived Nitric Oxide and Control of Vascular Tone, Hypertension, Cardiac Arrhythmias, Cardiovascular Gene Therapy. **Pulmonology:** Asthma, Pulmonary Emphysema. Lung Cancer: The Role of Tumor Suppressor Genes – Strategies for controlling the diseases.

Drugs acting on GIT: Antacids and anti-ulcer drugs, Laxatives and Anti-diarrheal drugs, Appetite stimulants and suppressants, Emetics and anti-emetics. Thyroid hormones and anti-thyroid drugs ACTH and corticosteroids, Androgens and anabolic steroids, oral contraceptives. Treatment of poisoning, Heavy metals and heavy metal antagonists, Acute, Sub acute and Chronic toxicity

Course Outcomes

After going through this course the student will be able to

CO1: Understand the 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

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. 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) Minor project.

Total CIE (Q+T+A) 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.

RESEARCH METHODOLOGY (Common to all programs)						
Course Code	**:**	**18IM23**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**08 Hrs**
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.	
Unit – II	**08 Hrs**
Data and data collection: Overview of probability and data types Primary 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	
Unit – III	**08 Hrs**
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	
Unit – IV	**08 Hrs**
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.	
Unit-V	**07 Hrs**
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	

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 by, Kothari C.R., 4th edition, New Age International Publishers,ISBN: 978-93-86649-22-5
2	Management Research Methodology, Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., 2006. Pearson Education: New Delhi, ISBN: 978-81-77585-63-6
3	The Research Methods Knowledge Base, William M. K. Trochim, James P. Donnelly, 3rd Edition, 2006. Atomic Dog Publishing, ISBN: 978-1592602919
4	Statistics for Management, Levin, R.I. and Rubin, D.S., Pearson Education: New Delhi. 7th Edition,

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. 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) Minor project.

Total CIE (Q+T+A) 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 (Professional Elective-C1)						
Course Code	:	**18MBT2C1**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**

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.

Unit –II	**08 Hrs**

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.

Unit –III	**08 Hrs**

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

Unit –IV	**08 Hrs**

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.

Unit –V	**07 Hrs**

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.

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.

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. 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) Minor project.
Total CIE (Q+T+A) 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 (Professional Elective-C2)						
Course Code	:	**18MBT2C2**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**

Introduction and basic concepts of classical plant breeding: The status of plant breeding in agriculture, the importance of breeding, history and development of plant breeding 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

Unit –II	**08 Hrs**

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.

Unit –III	**08 Hrs**

Alternative breeding techniques: Mutation breeding, induced mutagenesis, mutagens used, methods of working. Remote hybridization causes problems with pollination of species and the possibility of overcoming, the properties of distant hybrids.

Properties of polyploids, the use of polyploidy in plant breeding, methods of obtaining polyploid breeding, use of aneuploidy. Haploids in plant breeding. Breeding for resistance to pests and diseases, genetic nature of resistance.

Unit –IV	**07 Hrs**

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)

Unit –V	**08 Hrs**

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.

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

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. 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) Minor project.
Total CIE (Q+T+A) 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						
INSILICO DRUG DESIGN (Professional Elective-C3)						
Course Code	:	**18MBT2C3**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**

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

Unit –II	**08 Hrs**

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.

Unit –III	**08 Hrs**

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.

Unit –IV	**08 Hrs**

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.

Unit –V	**07 Hrs**

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

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.ISBN0123694485, 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

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. 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) Minor project.
Total CIE (Q+T+A) 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 (Professional Elective-D1)						
Course Code	:	**18MBT2D1**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**
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.	
Unit –II	**08 Hrs**
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.	
Unit –III	**08 Hrs**
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.	
Unit –IV	**08 Hrs**
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	
Unit –V	**07 Hrs**
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	

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.

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. 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) Minor project.
Total CIE (Q+T+A) 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 (Professional Elective-D2)						
Course Code	:	**18MBT2D2**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I	**08 Hrs**

Properties of foods and processing theory: Properties of liquids, solids and gases, Fluid flow through fluidized bed, Mechanisms of heat transfer, Sources of heat and methods of application to foods, Energy conservation Effect of heat on micro-organisms, Effect of heat on nutritional and sensory characteristics, Water activity, Effects of processing on sensory characteristics of foods, Effects of processing on nutritional properties, Food safety, good manufacturing practice and quality assurance

Unit –II	**08 Hrs**

Ambient-temperature processing: Raw material preparation: Cleaning, Sorting, grading, peeling. Size reduction: Size reduction of solid and liquid foods: theory, equipment and effects on food. Mixing and forming. separation and concentration of food components, Processing using electric fields: high hydrostatic pressure, light or ultrasound, irradiation: theory, equipment and effect on food.

Unit –III	**08 Hrs**

Processing by application of heat (theory, equipment and effect on foods): Heat processing using steam or water, Blanching, Pasteurization, Heat sterilization, Extrusion, Heat processing using hot air(theory, equipment and effect on foods): Dehydration, Baking and roasting, Heat processing by direct and radiated energy: Dielectric, ohmic and infrared heating. Heat processing using hot oils: theory equipment and effects on food of frying

Unit –IV	**08 Hrs**

Processing by the removal of heat: Chilling, Controlled- or modified-atmosphere storage and packaging, Freezing and concentration. Post-processing operations: coating or enrobing, Packaging: theory and types of packaging materials, Printing, Interactions between packaging and foods. Environmental considerations. Filling and sealing of containers: Rigid and semi-rigid containers, flexible containers, Types of sealer, Shrink-wrapping and stretch-wrapping, Tamper-evident packaging, Labelling, Materials handling, storage and distribution.

Unit –V	**07 Hrs**

Prebiotics, probiotics and nutraceuticals: Food Pyramid, Concept of prebiotics and probiotics - principle, mechanism and applications of probiotics, prebiotics Synbiotics for maintaining good health. Source of omega - 3 fatty acids, formulations, bioavailability, bioequivalence, Commercialization and Potential of Nutrigenetics and Nutrigenomics

Course Outcomes

After going through this course the student will be able to

CO1:Remember and apply the properties of food during processing of food

CO2: Know the application of biotechnology for food preservation and food production with improved nutritional benefits.

CO3:Acquire and apply various food processing techniques to increase the nutritional content and shelf life of food.

CO4: Evaluate and analyze the current ongoing research in nutraceuticals.

Reference Books:

1	Food Processing Technology: Principles and Practice, Fellows, P.J, Woodhead Publishing limited, Cambridge, 2nd edition, 2009. ISBN 978-1-84569-216-2
2	Introduction to Food Engineering,R. Paul Singh and Dennis R. Heldman, Academic Press, Elsevier, 5th ed., 2013.ISBN 9780123985309
3	Food Process Engineering Operations, George D. Saravacos and Zacharias B. Maroulis,, 1st ed. 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

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. 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) Minor project.
Total CIE (Q+T+A) 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 (Professional Elective-D3)						
Course Code	:	**18MBT2D3**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**3:1:0**		**SEE Marks**	:	**100**
Hours:	:	**39L+26T**		**SEE Duration**	:	**3Hrs**

Unit-I — **08 Hrs**

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.

Unit –II — **08 Hrs**

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.

Unit –III — **08 Hrs**

Big Data analytics

Introduction of Cloud computing, Hadoop architecture. MIKE2.0, Multiple layer architecture, Distributed Parallel architecture, NGS data analysis using Hadoop.

Unit –IV — **08 Hrs**

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.

Unit –V — **07 Hrs**

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.

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

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. 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) Minor project.
Total CIE (Q+T+A) 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						
BUSINESS ANALYTICS (Global Elective-G01)						
Course Code	**:**	**18CS2G01**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

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.	**08 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.	**08 Hrs**
Unit – III	
Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contributionofBusinessanalytics,ManagingChanges.DescriptiveAnalytics,Predictive Analytics, Predicative Modelling, Predictive analytics analysis.	**08 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 ForecastingModels.	**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**

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 FT Press Analytics, Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, 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: 978-0321997821 ISBN-10: 0321997824
4	Predictive Business Analytics Forward Looking Capabilities to Improve Business, Gary Cokins and Lawrence Maisel, Wiley; 1st Edition, 2013.

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. 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) Minor project.

Total CIE (Q+T+A) 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					
INDUSTRIAL AND OCCUPATIONAL HEALTH AND SAFETY (Global Elective-G02)					
Course Code	**:**	**18CV2G02**	**CIE**	**:**	**100 Marks**
Credits L: T: P	**:**	**3:0:0**	**SEE**	**:**	**100 Marks**
Hours	**:**	**39L**	**SEE Duration**	**:**	**3 Hrs**

UNIT – I	07 Hrs

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 fire fighting, equipment and methods.

UNIT – II	09 Hrs

Occupational health and safety: Introduction, Health, Occupational health: definition, Interaction between work and health, Health hazards, 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, Evaluation of health hazards: Exposure measurement techniques, Interpretation of findings recommended exposure limits. Controlling hazards: Engineering controls, Work practice controls, Administrative controls. Occupational diseases: Definition, Characteristics of occupational diseases, Prevention of occupational diseases.

UNIT – III	09 Hrs

Hazardous Materials characteristics and effects on health: Introduction, Chemical Agents, Organic Liquids, Gases, Metals and Metallic Compounds, Particulates and Fibers, Alkalies and Oxidizers, General Manufacturing Materials, Chemical Substitutes, Allergens, Carcinogens, Mutagens, Reproductive Hazards, Sensitizers and Teratogens, Recommended Chemical Exposure Limits. Physical Agents, Noise and Vibration, Temperature and Pressure, Carcinogenicity, Mutagenicity and Teratogenicity. Ergonomic Stresses:Stress-RelatedHealthIncidents,Eyestrain,RepetitiveMotion,LowerBackPain,VideoDisplay Terminals.

UNIT – IV	07 Hrs

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.

UNIT – V	07 Hrs

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components,
over hauling 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.

Course Outcomes After successful completion of 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 InformationServices.
2.	H. P. Garg, Maintenance Engineering Principles, Practices & Management, 2009,S. Chand and Company, New Delhi, ISBN:9788121926447
3.	Fundamental Principles of Occupational Health and Safety, Benjamin O. ALLI, Second edition,2008 International Labour Office – Geneva: ILO, ISBN 978-92-2-120454-1
4.	Foundation Engineering Handbook, 2008, Winterkorn, Hans, Chapman & Hall London. ISBN:8788111925428.

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. 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) Minor project.

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-G03)						
Course Code	**:**	**18IM2G03**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

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

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

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

CIE is executed by way of Quizzes (Q), Tests (T) and 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. 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.

Seminar/new developments in the related course 3) Laboratory/field work 4) Minor project.

Total CIE (Q+T+A) 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-G04)						
Course Code	**:**	**18IM2G04**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**08 Hrs**
Introduction: Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS), Introduction to Agile Methodology.	
Unit – II	**08 Hrs**
Capital Budgeting: Capital Investments: Importance and Difficulties, phases of capital budgeting, levels of decision making, facets of project analysis, feasibility study – a schematic diagram, objectives of capital budgeting	
Unit – III	**08 Hrs**
Project Costing: Cost of Project, Means of Finance, Cost of Production, Working Capital Requirement and its Financing, Profitability Projections, Projected Cash Flow Statement, Projected Balance Sheet, Multi-year Projections, Financial Modeling, Social Cost Benefit Analysis	
Unit – IV	**08Hrs**
Tools & Techniques of Project Management: Bar (GANTT) chart, bar chart for combined activities, logic diagrams and networks, Project evaluation and review Techniques (PERT) Critical Path Method (CPM), Computerized project management	
Unit-V	**07 Hrs**
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.	

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, 8th Edition, 2010, Tata McGraw Hill Publication, 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, 11th Edition, 2013, John Wiley & Sons Inc., ISBN 978-1-118-02227-6.
4	Project Management – Planning and Controlling Techniques, Rory Burke, 4th Edition, 2004, John Wiley & Sons, ISBN:9812-53-121-1

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. 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) Minor project.

Total CIE (Q+T+A) 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					
ENERGY MANAGEMENT (Global Elective-G05)					
Course Code	**:**	**18CH2G05**	**CIE**	**:**	**100 Marks**
Credits L: T: P	**:**	**3:0:0**	**SEE**	**:**	**100 Marks**
Hours	**:**	**39L**	**SEE Duration**	**:**	**3 Hrs**

Unit-I	**08 Hrs**

Energy conservation:
Principles of energy conservation, Energy audit and types of energy audit, Energy conservation approaches, Cogeneration and types of cogeneration, Heat Exchangers and classification.

Unit-II	**08 Hrs**

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

Unit –III	**08 Hrs**

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.

Unit –IV	**08Hrs**

Solar Photovoltaic:
Principle of photovoltaic conversion of solar energy, Types of solar cells and fabrication.
Wind Energy:
Classification, Factors influencing wind, WECS & classification.

Unit –V	**07 Hrs**

Alternative liquid fuels:
Introduction, Ethanol production: Raw materials, Pre-treatment, Conversion processes with detailed flow sheet. Gasification of wood: Detailed process, Gas purification and shift conversion, Biofuel from water hyacinth.

Course Outcomes
After successful completion of 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	Nonconventional energy, Ashok V Desai, 5th Edition, 2011, New Age International (P) Limited, ISBN 13: 9788122402070.
2	Biogas Technology - A Practical Hand Book, Khandelwal K C and Mahdi S S, Vol. I & II, 1986, McGraw-Hill Education, ISBN-13: 978-0074517239.
3	Biomass Conversion and Technology, Charles Y Wereko-Brobby and Essel B Hagan,1st Edition, 1996, John Wiley & Sons, ISBN-13: 978-0471962465.
4	Solar Photovoltaics: Fundamental Applications and Technologies, C. S. Solanki, 2nd Edition, 2009, Prentice Hall of India, ISBN:9788120343863.

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. 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) Minor project.

Total CIE (Q+T+A) 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						
INDUSTRY 4.0 (Global Elective-G06)						
Course Code	**:**	**18ME2G06**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**07 Hrs**
Introduction: Industrial, Internet, Case studies, Cloud and Fog, M2M Learning and Artificial Intelligence, AR, Industrial Internet Architecture Framework (IIAF), Data Management.	
Unit – II	**08 Hrs**
The Concept of the IIoT: Modern Communication Protocols, Wireless Communication Technologies, Proximity Network Communication Protocols, TCP/IP, API: A Technical Perspective, Middleware Architecture.	
Unit – III	**08 Hrs**
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. 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.	
Unit – IV	**08 Hrs**
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. Advances in Virtual Factory Research and Applications, The State of Art, The Virtual Factory Software , Limitations of the Commercial Software	
Unit –V	**08 Hrs**
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 wayforward. A Roadmap: Digital Transformation, Transforming Operational Processes, Business Models, Increase Operational Efficiency, Develop New Business Models.	

Course Outcomes

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

CO1: Understand the opportunities, challenges brought about by Industry 4.0 for benefits of organizations and individuals

CO2: Analyze the effectiveness of Smart Factories, Smart cities, Smart products and Smart services

CO3: Apply the Industrial 4.0 concepts in a manufacturing plant to improve productivity and profits

CO4: Evaluate the effectiveness of Cloud Computing in a networked economy

Reference Books

1	Industry 4.0 the Industrial Internet of Things, Alasdair Gilchrist, Apress Publisher, ISBN-13 (pbk): 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	Designingtheindustry - Internet of things connecting the physical, digital and virtual worlds, OvidiuVermesan and Peer Friess, Rivers Publishers, 2016 ISBN978-87-93379-81-7
4	The concept Industry 4.0- An Empirical Analysis of Technologies and Applications in Production Logistics, Christoph Jan Bartodziej, Springer Gabler, 2017 ISBN 978-3-6581-6502-4.

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. 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) Minor project.

Total CIE (Q+T+A) 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-G07)						
Course Code	**:**	**18ME2G07**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**07 Hrs**
Classification and Selection of Materials: Classification of materials. Properties required in Engineering materials, Criteria of selection of materials. Requirements / needs of advance materials.	
Unit – II	**08 Hrs**
Non Metallic Materials: Classification of n 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.	
Unit – III	**08 Hrs**
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	
Unit – IV	**08 Hrs**
Low & High Temperature Materials 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.	
Unit –V	**08 Hrs**
Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials	

Course Outcomes

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

CO1: Describe metallic and non metallic 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 L. Timp, 1999th Editionmm Springer, 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

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. 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) Minor project.

Total CIE (Q+T+A) 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 (Global Elective-08)						
Course Code	**:**	**18CHY2G08**		**CIE Marks**	**:**	**100**
CreditsL:T:P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit-I	**08 Hrs**

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, Particlereinforced
composites, Fibre reinforced composites. Fiber production techniques for glass, carbon and ceramic fibers Applications of various types of composites.

Unit – II	**08 Hrs**

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**.**

Unit -III	**08 Hrs**

Ceramic matrix composites and special composites

Engineering ceramic materials – properties – advantages – limitations – monolithicceramics
– 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.

Unit –IV	**07 Hrs**

Metal matrix composites

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 metallurgyprocess–diffusionbonding–stircasting–squeezecasting,asprayprocess,
Liquid infiltration In-situ reactions-Interface-measurement of interface properties- applications of MMC in aerospace, automotive industries.

Unit –V	**08 Hrs**

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.
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,2012 , ISBN: 978-0387743646
2	The Science and Engineering of Materials, K Balani, Donald R Askeland, 6th Edition- Cengage, Publishers,2013, ISBN: 13: 978-8131516416
3	Polymer Science and Technology, Joel R Fried , 2nd Edition, Prentice Hall, 2014, ISBN: 13: 978-0137039555
4	Nanomaterials and nanocomposites, Rajendra Kumar Goyal , 2nd Edition,CRC Press-Taylor & Francis, 2010, ISBN: 10-9781498761666, 1498761666

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. 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

Seminar/new developments in the related course 3) Laboratory/field work 4) Minor project.

Total CIE (Q+T+A) 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-09)						
Course Code	**:**	**18PHY2G09**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I **08 Hrs**

Crystal Structure

Discussion of lattice and lattice parameters, seven crystals systems, crystal planes, Miller indices, Interplanar distance, Packing fraction, Structure of different crystals-NaCl and Diamond, Bragg's law, Powder method, Bragg's spectrometer, Qualitative Analysis of Crystal structure using XRD, Reciprocal lattice, Crystal defects-Point, Line, Planar and Volume defects.

Unit – II **08 Hrs**

Dielectric Materials

Basic concepts, Langevin's Theory of Polarisation, Types of Polarisation, Dipolar relaxation, Frequency Dependence of total polarization (polarizability as a function of frequency), Qualitative discussion of Internal Field and ClaussiusMossotti, Dielectric loss spectrum, Dielectric strength, Dielectric Breakdown, Breakdown mechanisms in solid dielectrics, Applications of Solid Insulating materials in capacitors and Liquid insulating materials in Transformers, Dielectric Heating, Piezoelectricity, Direct and Inverse Piezoelectric effect,

Coupling factor, spontaneous polarization, Piezolelectricty in Quartz, Various piezoelectric materials-PZT, PVDF, Ferroelectricity, Barium titanate, Poling in Ceramics.

Unit – III **08 Hrs**

Magnetic Materials

Review of Dia, Para and Ferromagnetic materials, Weiss theory of Ferromagnetism, Hysteresis effect, Magnetostriction, Anti-ferromagnetism, Ferrimagnetsim, Soft and Hard magnetic materials, examples and applications in Transformer cores and Magnetic storage devices, Superconductors, properties, Types of Superconductors, BCS theory, High Temperature Superconductors, Applications in Cryotron and SQUID.

Unit – IV **07 Hrs**

Semiconducting Materials

Semiconductors-Direct and Indirect band gap semiconductors, Importance of Quantum confinement-quantum wires and dots, size dependent properties, Top down approach, Fabrication process by MillingandLithography,Bottomupapproach,fabricationprocessbyvapourphaseexpansionand vapor phase condensation, Polymer semi-conductors-Photo conductive polymers, Applications.

Unit –V **08 Hrs**

Novel Materials

Smart materials-shape memory alloys, Austenite and Martensite phase, Effect of temperature and mechanical load on phase transformation, Pseudoeleasticity, Transformation hysteresis, Superelasticity, Characterization technique-Differntial Scanning calorimetry, Preparation technique-spin coating, Nitinol, CuAlNi alloy andapplications.

Biomaterials-Metallic, ceramic and polymer biomaterials, Titanium and Titanium alloys, Carbon nanotubes, Graphene- Properties and Applications.

Course Outcomes

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

CO1: Apply the principles of Physics in Engineering.

CO2: Apply the knowledge of Physics for material analysis.

CO3: Identify and Analyze Engineering Problems to achieve practical solutions.

CO4: Develop solutions for Problems associated with Technologies.

Reference Books	
1.	Solid State Physics, S O Pillai, 6th Edition, New Age International Publishers, ISBN10-8122436978.
2.	Introduction to Solid State Physics, C.Kittel, 7th Edition, 2003, John Wiley & Sons, ISBN 9971-
	51-180.
3.	Engineering Physics, Dr.M N Avadhanulu, Dr. P G Kshirsagar, S Chand Publishing, Reprint 2015.
4.	The Science and Engineering of Materials, Askeland, Fulay, Wright, Balanai, 6th Edition, Cengage Learning, ISBN-13:978-0-495-66802-2.

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. 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

Seminar/new developments in the related course 3) Laboratory/field work 4) Minor project.

Total CIE (Q+T+A) 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 STATISTICAL METHODS (Global Elective-G10)						
Course Code	**:**	**18MAT2G10**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**07 Hrs**
Sampling Techniques: Concepts of random sampling from finite and infinite populations, Simple random sampling (with replacement and without replacement), Sampling distribution of proportions, Expectation and standard error of sample mean and proportion, Sampling distributions ofdifferences and sums.	
Unit – II	**08 Hrs**
Estimation: Point estimation, Estimator and estimate, Criteria for good estimates - unbiasedness, consistency, efficiency and sufficiency, Method of moment's estimation and maximum likelihood estimation, Confidence intervals-population mean (large sample).	
Unit – III	**08 Hrs**
Tests of Hypothesis: Principles of Statistical Inference, Formulation of the problems with examples. Simple and composite hypotheses. Null and alternative hypotheses. Tests - type I and type II error, Testing of mean and variance of normal population (one sample and two samples), Exact and asymptotic tests of proportions. Chi squared test for goodness of fit (Relevant case studies).	
Unit – IV	**07 Hrs**
Linear Statistical Models: Definition of linear model and types, One way ANOVA and two way ANOVAmodels-oneobservationpercell,multiplebutequalnumberofobservationpercell(Relevant case studies).	
Unit –V	**09 Hrs**
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.	

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: Analyse 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), A. M. Goon, M. K. Gupta and B. Dasgupta, 3rd Edition, 1968, World Press Private Limited, ISBN-13: 978-8187567806.
2.	Applied Statistics and Probability for Engineers, Douglas C. Montgomery and George C. Runger, 6th Edition, John Wiley & Sons, 2014, ISBN:13 9781118539712, ISBN (BRV):9781118645062.
3.	Fundamentals of Mathematical Statistic-A Modern Approach, S.C. Gupta and V.K. Kapoor, 10th Edition, 2000, S Chand Publications, ISBN: 81-7014-791-3.
4.	Regression Analysis: Concepts and Applications, F. A. Graybill and H. K. Iyer, Belmont, Calif, 1994, Duxbury Press, ISBN-13: 978-0534198695.

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. 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

Seminar/new developments in the related course 3) Laboratory/field work 4) Minor project.

Total CIE (Q+T+A) 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						
MINOR PROJECT						
Course Code	**:**	**18MBT24**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**0:0:2**		**SEE Marks**	**:**	**100**
Hours/Week	**:**	**4**		**SEE Duration**	**:**	**3 Hrs**

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 completing the 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

Evaluation will be carried out in 3 phases. The evaluation committee will comprise of 4 members: Guide, Two Senior Faculty Members and Head of the Department.

Phase	Activity	Weightage
I	Synopsys 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%

** 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 of Semester End Examination (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.

- Brief write up about the project 05%
- Presentation / Demonstration of the Project 20%
- Methodology and Experimental results & Discussion 25%
- Report 20%
- Viva Voce 30%

SYLLABUS
FOR
SEMESTER III & IV

SEMESTER: III						
DOWNSTREAM PROCESS TECHNOLOGY (Theory And Practice)						
Course Code	**:**	**18MBT31**		**CIE Marks**	**:**	**100+50**
Credits: L:T:P	**:**	**4:0:1**		**SEE Marks**	**:**	**100+50**
Hours	**:**	**52L+26P**		**SEE Duration**	**:**	**3Hrs**

Unit-I	**09 Hrs**

Introduction

Introduction to downstream processing, Recovery of intracellular and extracellular products, cell disruption techniques, separation by settling, terminal settling velocity, batch settling, Kynch Theory. Numericals

Unit –II	**11 Hrs**

Filtration and Purification: Filtration

Pre-filtration, depth filtration, mechanism of depth filtration, modules of depth filtration. Flow rates and pressure variations in depth filtration. Membrane filtration, microfiltration, ultrafiltration, Diafiltration, cross-flow filtration, transmembrane pressure and Flux calculations with numerical.

Virus removal methods

Viral removal and deactivation methods, Viral filtration, uv-radiation, membrane filtration for virus removal. Methods of operation and scale-up activities for viralclearance.

Unit –III	**12 Hrs**

Chromatography

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

Unit –IV	**10 Hrs**

Drying

Drying curve, Batch and continuous dryers, Freeze drying, spray drying. Crystallization: Principles of crystallization. Extraction: process details, selection of solvent, percentage extraction, distribution coefficient. Adsorption: Types of adsorption, different adsorbents, isotherms.

Unit –V	**10 Hrs**

Current Scenario in the bioprocess industries

Process design criteria for low volume high value products and high volume low value products. Process economics: cost cutting strategies, costing for purification of a by-product.

Case-Studies

Purification Case studies on monoloclonal antibodies (mAbs), recombinant proteins, bacterial vaccines, traditional and cell culture based viral vaccines. Downstream processing of albumin and clotting factors.

Unit-VI (Practical component)	26 Hrs

1) Cell disruption of intracellular biomolecules (ex: yeast cells) and to assay the total protein or enzyme content
2) Calculation of terminal settling velocity of disrupted yeast cells under the influence of flocculants & to design of thickener for batch sedimentation (under gravity) using Kynch's theory
3) Determination of clean water flux (CWF) and to calculate the flux and area of membrane required for the clarification of known cell broth (ex: yeast cells) in given time
4) Extraction of an antibiotic (ex: ceftriaxone and sulbatum) using different aqueous-organic solvent systems and determination of distribution coefficient and percentage extraction.
5) To carry out bulk precipitation of protein/enzyme from given suspension (ex; yeast cells) using ammonium sulfate and find the % cut of ammonium sulfate where the protein is highest precipitated
6) Determination of the partition coefficient and yield of total protein present in intracellular or extracellular compounds (such as yeast cells/pigments) using Polyethylene Glycol and salt system in single and/or multiple stages.
7) Extraction of amylase from fungal sources and its estimation
8) Determination of the constants of Freundlich equation by adsorbing BSA on silica.
9) Determination of the rate of drying for the given sample in a vacuum tray drier or by osmotic dehydration (ex: vegetables such as potatoes)
10) Purification of biomolecules (ex: pigments) using gel chromatography or ion exchange chromatography

Course Outcomes

After going through this course the student will be able to

CO1: Summarize the current process involved in industrial purification of biological products

CO2: Acquire the knowledge on different filtration and purification techniques.

CO3: Understand the different types of chromatography and viral reduction, removal and its importance

CO4: Overview on case studies pertaining to bioproducts currently in market

Reference Books:

1	Process Scale Purification of Antibodies, Uwe Gottschalk, 2nd edition, John Wiley & Sons,2017,ISBN: 978-1-119-12691-1
2	Bioseparations Science and Engineering, Harrison R.G. Todd P. Rudge S.R. and D.P. Petrides, 2nd edition, Oxford University Press, 2015, ISBN: 9780195391817
3	Principles of Downstream Processing in Biological and Chemical Processes, MokeshDoble, 1st edition. CRC Press, Taylor & Francis group, 2015, ISBN 9781771881401
4	Downstream Process Technology: A New Horizon in Biotechnology, Nooralabettu Krishna Prasad, 1st edition, PHI Learning Publications, 2010, ISBN: 978-81-203-4040-4

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.**

Continuous Internal Evaluation (CIE); Practical (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.

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

SEMESTER: III						
INTERNSHIP						
Course Code	**:**	**18MBT32**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**0:0:5**		**SEE Marks**	**:**	**100**
Hours/week	**:**	**10**		**SEE Duration**	**:**	**3 Hrs**

GUIDELINES

1) The duration of the internship shall be for a period of 8 weeks on full time basis after II semester final exams and before the commencement of III semester.
2) The student must submit letters from the industry clearly specifying his / her name and the duration of the internship on the company letter head with authorized signature.
3) Internship must be related to the field of specialization of the respective PG programme in which the student has enrolled.
4) Students undergoing internship training are advised to report their progress and submit periodic progress reports to their respective guides.
5) Students have to present the internship activities carried out to the departmental committee and only upon approval by the committee, the student can proceed to prepare and submit the hard copy of the final internship report. However, interim or periodic reports as required by the industry / organization can be submitted as per the format acceptable to the respective industry /organizations.
6) The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be Ivory color for PG circuit Programs and Light Blue for Non-Circuit Programs.
7) The broad format of the internship final report shall be as follows
    - Cover Page
    - Certificate from College
    - Certificate from Industry / Organization
    - Acknowledgement
    - Synopsis
    - Table of Contents
    - Chapter 1 - Profile of the Organization : Organizational structure, Products, Services, Business Partners, Financials, Manpower, Societal Concerns, Professional Practices,
    - Chapter 2 - Activities of the Department
    - Chapter 3 - Tasks Performed : summaries the tasks performed during 8 week period
    - Chapter 4 – Reflections : Highlight specific technical and soft skills that you acquired during internship
    - References & Annexure

Course Outcomes

After going through the internship the student will be able to:

CO1: Apply engineering and management principles

CO2: Analyze real-time problems and suggest alternate solutions

CO3: Communicate effectively and work in teams

CO4: Imbibe the practice of professional ethics and need for lifelong learning.

Scheme of Continuous Internal Evaluation (CIE):

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

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

Reviews	Activity	Weightage
Review-I	Explanation of the application of engineering knowledge in industries, ability to comprehend the functioning of the organization/ departments,	45%
Review-II	Importance of resource management, environment and sustainability presentation skills and report writing	55%

Scheme for Semester End Evaluation (SEE):

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

SEMESTER: III						
MAJOR PROJECT : PHASE-I						
Course Code	**:**	**18MBT33**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**0:0:5**		**SEE Marks**	**:**	**100**
Hours/week	**:**	**10**		**SEE Duration**	**:**	**3 Hrs**

GUIDELINES

1. The Major Project work comprises of Phase-I and Phase-II. Phase-I is to be carried out in third semester and Phase-II in fourth semester.
2. The total duration of the Major project Phase-I shall be for 16 weeks.
3. Major project shall be carried out on individual student basis in his/her respective PG programme specialization. Interdisciplinary projects are also considered.
4. The allocation of the guides shall be preferably in accordance with the expertise of the faculty.
5. The project may be carried out on-campus/industry/organization with prior approval from Internal Guide, Associate Dean and Head of the Department.
6. Students have to complete Major Project Phase-I before starting Major Project Phase-II.
7. The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be Ivory color for PG circuit Programs and Light Blue for Non-Circuit Programs.

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 project and resource managements skills, professional ethics, societal concerns
CO4: Synthesize self-learning, sustainable solutions and demonstrate life-long learning

Scheme of Continuous Internal Examination (CIE)

Evaluation shall be carried out in two reviews. The evaluation committee shall consist of Guide, Professor and Associate Professor/Assistant Professor.

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

Reviews	Activity	Weightage
Review-I	Selection of the topic, Literature Survey, Problem Formulation and Objectives	45%
Review-II	Methodology and Report writing	55%

Scheme for Semester End Evaluation (SEE):

Major Project Phase-I evaluation shall be done by an external examiner (domain expert) and respective guide as per the schedule. Maximum of four candidates per batch shall be allowed to take examination. The batches are to be formed based on specific domain of work.

SEMESTER: III						
NANOBIOTECHNOLOGY (Professional Elective-E1)						
Course Code	**:**	**18MBT3E1**		**CIE Marks**	**:**	**100**
Credits: L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**3Hrs**

Unit-I	**10 Hrs**

Fundamentals of Nanotechnology and Nanoengineering

History, Types of nanomaterials: Fullerenes, Nanoshells, Quntum dots, Dendrimers, Nanocarriers. **Nanobiomaterials:** DNA and Protein based Nano structures, array nanostructures. Function and application of DNA and protein based nanostructures. **Bionanomaterials in Nature:** Lotus leaf as a model self cleansing system as example, case studies

Unit –II	**11 Hrs**

Nanomaterials, Synthesis and Characterization

Approaches of Fabrication: Top-Down and Bottom-up methods of nanofabrication and Nanosynthesis: Ball milling, CVD, Sol gel, Plasma arching. Biosynthesis of Nanoparticles. Nanolithography: hard (Optical, UV, EUV, X-ray)and soft lithography. Characterization of nanomaterials using spectroscopic (UV-VIS, FTIR and Raman) and microscopic methods (SEM, TEM, STM and AFM).

Unit –III	**10 Hrs**

Micro & Nano Electromechanical systems and Microfluidics

MEMS/NEMS/BioNEMS: Types of transducers: mechanical, optical, magnetic and chemical transducers. Nano sensors and actuators, Microfludics:Laminar flow, Hagen-Poiseuille equation, basic fluid ideas, Special considerations of flow in small channels, micro mixing, microvalves and micropumps.

Unit –IV	**10 Hrs**

Nanosensors

Types of Nanosensors and their applications. Electromagnetic nanosensors: Electronic nose and electronic tongue, Magnetic nanosensors. Mechanical nanosensors: Cantilever Nanosensors,**NanoBiosensors**: NanoBiosensors in modern medicine. Nanofabricated devices to separate and interrogate DNA, Interrogation of immune and neuronal cell activities through micro- and nanotechnology based tools and devices.

Unit –V	**11 Hrs**

Medical Nano biotechnology in Diagnostics, therapeutics, drug delivery, Nano Surgery and Tissue Engineering. Drug Delivery Applications, Bioavailability, Sustained and targeted release. Benefits of Nano drug delivery system. Use of Microneedles and nanoparticles for targeted and highly controlled drug delivery. Nano robots in drug delivery and cleaning system. Design of nanoparticles for oral delivery of peptide drugs. Nanotoxicity assessment: In-vitro laboratory tests on the interaction of nanoparticles with cells. Body on a chip and lab on a chip.

Course Outcomes

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

CO1: Understand and apply the knowledge of nanomaterials and nanobiomaterials to enable health sector advancements.

CO2: Interpret and apply the techniques of manufacturing and characterization processes.

CO3: Apply the knowledge for various applications in Biomedical field.

CO4: Design devices and systems for various biological applications

Reference Books:	
1.	Introduction to Nanosciences, Gabor L. H., Dutta J., Tibbals H. F., Rao A., CRC press, 2008, ISBN- 1420048058
2.	Textbook of Nanosciences and Nanotechnology, Murthy B.S., Shankar P., Raj,B., Rath, B.B. and Murday, J., Springer, Co-publication with University Press (India) Pvt. Ltd. VCH, XII, 2013, ISBN- 978-3-642-28030-6.
3.	Nanosensors: Physical, Chemical and Biological, Vinod kumar Khanna, CRC press, 2013, ISBN 9781439827123
4.	NanoBiotechnology Protocols, Sandra J. Rosenthal, David W. Wright, 2nd edition, Springer, Humana Press, 2013, ISBN- 13 978-158829276

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. 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) Minor project.
Total CIE (Q+T+A) 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: III						
BIOBUSINESS, PROJECT MANAGEMENT AND ECONOMICS (Professional Elective-E2)						
Course Code	**:**	**18MBT3E2**		**CIE Marks**	**:**	**100**
Credits: L:T:P	**:**	**4:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**52L**		**SEE Duration**	**:**	**3Hrs**

Unit-I	**10 Hrs**

Introduction

Project, Project management, portfolio management, program management, organizational project management, operations management and organizational strategy, role of the project manager.

Generation and Screening of Project Ideas and project life cycle: Generation and preliminary screening of ideas, project state holders & governance, project team, project life cycle

Unit –II	**12 Hrs**

Limbs of project management

Project Integration Management: Develop project charter, develop project management plan, Project Scope Management: create and validate WBS, validateProject Quality management: quality assurance, control quality. Project Risk Management: identify risks, risk analysis, plan risk resources, control risk.

Network Techniques for Project Management: Development of project network, time estimation, determination of the critical path, scheduling when resources are limited, PERT model. CPM model.

Unit –III	**10 Hrs**

Introduction to Economics

Concept of Economy and its working, basic problems of an Economy, Market mechanism to solve economic problems, Essentials of Micro Economics: Concept and scope, tools of Microeconomics, Uses of Microeconomics. Essentials of Macroeconomics**:** Prices and inflation, Exchange rate, Gross domestic product(GDP) , components of GDP, the Labor Market, Money and banks, Interest rate.

Unit –IV	**10 Hrs**

Biomanufacturing

Overview of biomanufacturing requirements, Design in biomanufacture, technical considerations for biomanufacturing, life cycle, GMP, GLP & NABL, Quality System Regulations (QSR), Good Manufacturing Practice (GMP), Good Laboratory Practices (GLP), Good Clinical Practice (GCP), and FDA. Elements of quality system, Unique approaches to quality management: Risk based approach, ISO, TQM and six sigma, quality systems for research

Unit –V	**10 Hrs**

Bioenterprises

Business plans, Business models, funding of biotech business: Financing alternatives, Angel funding, Venture Capital funding, funding for biotech in India, Exit strategy, licensing strategies and valuation. Business laws applied to Biotech industries in India. funding agencies in India and biotech policy initiatives. Bio entrepreneurship in India. History of pioneer biotech companies: Alembic, Shanta Biotech &Biocon,

Course Outcomes	
After going through this course the student will be able to	
CO1: Explain and comprehend the concept of project management, economics and bio business.	
CO2: Appraise and illustrate various project management processes in the project management framework.	
CO3: Analyze, plan and develop quality control & assurance along with economics for development of biobusiness for sustenance.	
CO4: Develop project plans and apply project management techniques to monitor, review and evaluate progress on different types of project.	
Reference Books	
1	Project Management Institute, "A Guide to the Project Management Body of Knowledge (PMBOK Guide)", 5th Edition, 2013, ISBN: 978-1-935589-67-9
2	Project Management A System approach to Planning Scheduling & Controlling, Harold Kerzner, 11th Edition, John Wiley & Sons Inc., 2013, ISBN 978-1-118-02227-6.
3	Management, Stephen Robbins, Mary Coulter &NeharikaVohra, 10th Edition, Pearson Education Publications, 2010, ISBN: 978-81-317-2720-1.
4	Macroeconomics: Theory and Policy, Dwivedi D.N, 3rd Edition, McGraw Hill Education, 2010, ISBN-13: 978-0070091450.

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. 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) Minor project.
Total CIE (Q+T+A) 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: III						
NEXT GENERATION SEQUENCING TECHNOLOGY (Professional Elective-E3)						
Course Code	:	**18MBT3E3**		**CIE Marks**	:	**100**
Credits: L:T:P	:	**4:0:0**		**SEE Marks**	:	**100**
Hours:	:	**52L**		**SEE Duration**	:	**3Hrs**

Unit-I	**10 Hrs**

Introduction to Sequencing technology

Sequencing platforms, Chemistry of difference sequencing platforms, Advantages and disadvantages of the platforms, Need of Hybrid platforms. Base calling algorithms, Base quality, phred values, Reads quality checks, Interpretations from quality checks. Adapter and primer contamination. Processing reads using clipping of reads-Advantages and disadvantages of processing of reads

Unit –II	**12 Hrs**

Overview of NGS Application

Burrows-Wheeler Aligner (BWA) and Bowtie Alignment programs, burrows wheeler algorithm. Reference indexing and Alignment. Building from source, The bowtie aligner, The -n alignment mode, The -v alignment mode, Reporting Modes, Paired-end Alignment, Colorspace Alignment, Colorspace reads, Building a colorspace index, Decoding colorspace alignments, Paired-end colorspace alignment, Performance Tuning, SAM and BAM format. Artifacts in alignment programs

Whole Genome Sequencing, Human Exome sequencing, Transcriptome sequencing, chip Sequencing, smallRNA sequencing, Methylome sequencing, RAD Sequencing and RRL sequencing.

Unit –III	**11 Hrs**

Big Data Analytics

Introduction of Cloud computing, Hadoop architecture. MIKE2.0 , Multiple layer architecture, Distributed Parallel architecture , NGS data analysis using Hadoop,

HPC overview and programming :

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, HPC Data Storage, Serial and parallel batch jobs and scripting to run processes in parallel.

Unit –IV	**09 Hrs**

Tools and Techniques for high throughput data analysis

NGS data –Retrieval, Format Conversion, Quality Check, Trimming low quality reads, Alignment and Assembly, Visualization, Variant Calling, Annotation. Gene–Level Statistical Analyses, Identifying Functional Modules

Unit –V	**10 Hrs**

Clinical Applications

States of the genetic research for complex disease, NGS and genetics of complex disease, personal genome sequencing, Disease gene identification, Differential expression analysis, Next generation sequencing in cancer research, Clinical sequencing, Diagnostic NGS.

Course Outcomes

After going through this course the student will be able to

CO1: Understand the basic knowledge of Next Generation Sequencing

CO2: Analyze and apply the appropriate tools and techniques to perform high throughput data analysis

CO3: Design pipeline for various applications of NGS analysis

CO4: Develop high throughput data analysis tools for various biological applications.

Reference Books:	
1	Next-generation DNA sequencing informatics, Stuart M. Brown, Cold Spring Harbor Laboratory Press, Cold Spring Harbor: New York, 2015, ISBN-13: 978-1936113873.
2	Bioinformatics for High Throughput Sequencing,Naiara Rodríguez-Ezpeleta, Michael Hackenberg, Ana M. Aransay, Springer New York, 2011. ISBN-13: 9781461407812
3	High-Throughput Next Generation Sequencing Methods and Applications Series: Young Min Kwon, Steven C. Ricke, Humana Press ,2011, ISBN: 978-1-61779-088-1 (Print) 978-1-61779-089-8
4	Clinical Applications for Next-Generation Sequencing, UrszulaDemkow and RafalPloski, Academic Press, 2015, ISBN: 978-0-12-801739-5

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. 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) Minor project.
Total CIE (Q+T+A) 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: IV						
MAJOR PROJECT : PHASE-II						
Course Code	**:**	**18MBT41**		**CIE Marks**	**:**	**100**
Credits L:T:P	**:**	**0:0:20**		**SEE Marks**	**:**	**100**
Hours/Week	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

GUIDELINES

1. Major Project Phase-II is continuation of Phase-I.
2. The duration of the Phase-II shall be of 16 weeks.
3. The student needs to complete the project work in terms of methodology, algorithm development, experimentation, testing and analysis of results.
4. It is mandatory for the student to present/publish the work in National/International conferences or Journals
5. The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be Ivory color for PG circuit Programs and Light Blue for Non-Circuit Programs.

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 project and resource managements skills, professional ethics, societal concerns
CO4: Synthesize self-learning, sustainable solutions and demonstrate life-long learning.

Scheme of Continuous Internal Examination (CIE)

Evaluation shall be carried out in three reviews. The evaluation committee shall consist of Guide, Professor/Associate Professor and Assistant Professor.

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

Reviews	Activity	Weightage
Review-I	Review and refinement of Objectives, Methodology and Implementation	20%
Review-II	Design, Implementation and Testing	40%
Review-III	Experimental Result & Analysis, Conclusions and Future Scope of Work, Report Writing and Paper Publication	40%

Scheme for Semester End Evaluation (SEE):

Major Project Phase-II SEE shall be conducted in two stages. This is initiated after fulfilment of submission of project report and CIE marks.

Stage-1Report Evaluation

Evaluation of Project Report shall be done by guide and an external examiner.

Stage-2Project Viva-voce

Major Project Viva-voce examination is conducted after receipt of evaluation reports from guide and external examiner.

Both Stage-1 and Stage-2 evaluations shall be completed as per the evaluation formats.

SEE procedure is as follows:

	Internal Guide	**External Examiner**	**TOTAL**	
SEE Report Evaluation	100 marks	100 marks		200 marks
			(A)	(200/2) = 100 marks
Viva-Voce	Jointly evaluated by Internal Guide & External Evaluator		(B)	100 marks
			Total Marks	**[(A)+(B)]/2 = 100**

SEMESTER: IV						
TECHNICAL SEMINAR						
Course Code	**:**	**18MBT42**		**CIE Marks**	**:**	**50**
Credits L:T:P	**:**	**0:0:2**		**SEE Marks**	**:**	**50**
Hours/Week	**:**	**4**		**SEE Duration**	**:**	**30 Mins**

GUIDELINES

1) The presentation shall be done by individual students.
2) The seminar topic shall be in the thrust areas of respective PG programs
3) The seminar topic could be complementary to the major project work
4) The student shall bring out the technological developments with sustainability and societal relevance.
5) Each student must submit both hard and soft copies of the presentation along with the report.
6) The reports shall be printed on A4 size with 1.5 spacing and Times New Roman with font size 12, outer cover of the report (wrapper) has to be Ivory color for PG circuit Programs and Light Blue for Non-Circuit Programs.

Course Outcomes

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

CO1: Identify topics that are relevant to the present context of the world

CO2: Perform survey and review relevant information to the field of study.

CO3: Enhance presentation skills and report writing skills.

CO4: Develop alternative solutions which are sustainable.

Scheme of Continuous Internal Evaluation (CIE): Evaluation shall be carried out in two reviews. The evaluation committee shall consist of Guide, Professor/Associate Professor and Assistant Professor.

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

Reviews	Activity	Weightage
Review-I	Selection of Topic, Review of literature, Technical Relevance, Sustainability and Societal Concerns, Presentation Skills	45%
Review-II	Technological Developments, Key Competitors, Report writing	55%

Scheme for Semester End Evaluation (SEE):

The SEE examination shall be conducted by an external examiner and an internal examiner. Evaluation shall be done in batches, not exceeding 6 students per batch.