RV COLLEGE OF ENGINEERING®

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

Scheme and Syllabus of I to IV Semester

(Autonomous System of 2018 Scheme)

Master of Technology (M.Tech)
in
BIOINFORMATICS

DEPARTMENT OF
BIOTECHNOLOGY

VISION

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

MISSION

1. To deliver outcomebased 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)
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BIOINFORMATICS

DEPARTMENT OF
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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

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

PROGRAMME OUTCOMES (PO)

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

PO1: Independently carry out research and development work to solve biological problems using Information technology.

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: Perform in multidisciplinary teams at the interface of biotechnology, information technology & other allied fields with sound interpersonal, management and effective communication skills with a commitment to lifelong learning.

PO5: Execute projects effectively by applying principles of project management to optimize time, money and resources.

PO6: Design and evaluate products considering environment and sustainability to address Social, Public health, Ethical and Legal concerns.

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

CONTENTS

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DEPARTMENT OF BIOTECHNOLOGY

M.Techin BIOINFORMATICS

FIRST SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Credits**
1	18MAT11A	Applied Mathematics	MAT	4	0	0	4
2	18MBI12	Statistical programming using R	BT	4	0	1	5
3	18MBI13	Essentials of Computational Biology	BT	4	0	1	5
4	18MBI1AX	Elective Group-A	BT	3	1	0	4
5	18MBI1BX	Elective Group-B	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**	**Credits**
1	18MBI21	BioPerl and BioPython	BT	4	0	1	5
2	18MBI22	Bio-molecular modelling and simulation	BT	4	0	0	4
3	18MBI23	Research Methodology	BT	3	0	0	3
4	18MBI2CX	Group C: Core Elective	BT	3	1	0	4
5	18MBI2DX	Group D: Core Elective	BT	3	1	0	4
6	18XX2GXX	Global Elective	BT	3	0	0	3
7	18MBI24	Minor Project	BT	0	0	2	2
Total number of Credits				**20**	**2**	**3**	**25**
Total Number of Hours / Week				**20**	**4**	**6**	**30**

SEMESTER : I		
GROUP A: PROFESSIONAL ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	18MBI1A1	Data Structures using Python
2.	18MBI1A2	Genomics and Proteomics
3.	18MBT1A3	Shell Scripting
4.		
GROUP B: PROFESSIONAL ELECTIVES		
1.	18MBI1B1	Gene Expression Data Analysis & Visualization
2.	18MBI1B2	Ruby and BioRuby
3.	18MBT1B3	Systems Biology
4.		
SEMESTER : II		
GROUP C: PROFESSIONAL ELECTIVES		
1.	18MBI2C1	Algorithm design and analysis
2.	18MBI2C2	Android Programming
3.	18MBT2C3	Insilico Drug Design
4.		
GROUP D: PROFESSIONAL ELECTIVES		
1.	18MBI2D1	Java and J2EE
2.	18MBI2D2	Artificial Intelligence
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

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DEPARTMENT OF BIOTECHNOLOGY

M.Tech Program in BIOINFORMATICS

THIRD SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Credits**
1	18MBI31	Next Generation Sequencing Technology	BT	4	0	1	**5**
2	18MBI32	Internship	BT	0	0	5	**5**
3	18MBI33	Major Project Phase I	BT	0	0	5	**5**
4	18MBI3EX	ProfessionalElective -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: PROFESSIONALELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1	18MBI3E1	Advanced Data Science
2	18MBI3E2	Data mining and warehousing
3	18MBI3E3	Big data analytics and Applications

FOURTH SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Credits**
1	18MBI41	Major Project Phase II	BT	0	0	20	20
2	18MBI42	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						
Course Code	**:**	**18MAT11A**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**4:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**52L**		**SEE Duration**	**:**	**3Hrs**

Unit – I	**10Hrs**

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	**10Hrs**

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 completing the course, the students will be able to

CO1: Identify and interpret the fundamental concepts of statistics, distributions, linear algebra, differential equations and optimization arising in various fields engineering.

CO2: Apply the knowledge and skills of statistical/numerical/optimization techniques to solve problems of least squares, probability distributions, linear equations, Eigen value problems and differential equations which have great importance in science and engineering.

CO3: Analyse the physical problem to establish statistical/mathematical model and use appropriate method to solve and optimize the solution.

CO4: Distinguish the overall mathematical knowledge gained to demonstrate and analyse the problems of method of least squares, probability distributions, linear equations, Eigen value problems, differential equations andoptimization arising 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						
STATISTICAL PROGRAMMING USING R (Theory and Practice)						
Course Code	**:**	**18MBI12**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**4:0:1**		**SEE**	**:**	**100+50 Marks**
Hours	**:**	**52L+26P**		**SEE Duration**	**:**	**3+3 Hrs**

Unit – I	**11Hrs**
Introduction to R programming: Establishment of R programming, downloading and installation of R from CRAN on windows and Linux OS. Getting help from CRAN website and the internet and the help commands. Command packages: standard command packages, running and manipulating the commands.	
Unit – II	**10 Hrs**
Working with objects using R: Use of R as calculator, storing the results, reading and getting data to R, viewing the objects, types of data items, examining the data structure and working with previous commands. Saving the work in R. Manipulating objects: vectors, matrix and data frames. Constructing the data objects, testing and converting.	
Unit – III	**10 Hrs**
Descriptive statistics and tabulation: Sample summarization; vectors, cumulative statistics, data frames, matrix objects, lists. Making contingency tables, selecting the parts of a table object, complex tables, testing, cross tabulation.	
Unit – IV	**11 Hrs**
Data distribution: Stem and leaf plots, density functions. Types of data distribution: Normal and other distributions, random number generation and control, sampling, Shapiro-Wilk test for normality, Kolmogorov-Smirnov test Quantile-Quantile plots, Box-Whisker plots, Cleveland dot charts, bar charts, copy graphics.	
Unit – V	**10 Hrs**
Hypothesis testing and complex statistics: Student's t test, Wilcoxon U test (Mann-Whitney), correlation and covariance, Regression, Monte Carlo Simulation, Goodness of fit, ANOVA. Writing the own scripts.	
Unit – VI	**26 Hrs**

1. A. Write Linux environmental setup steps for R
   B. Perform a Bioconductor R package installation using R Console
   C. Create a vector with some of "Amino acids"
2. A. Get the length of the vector
   B. Print first and last amino acid
   C. Sort "Amino acids" vector in reverse order
3. A. Construct a matrix with 4 rows that contains the numbers 1 up to 12.
   B. Create two 2x3 matrices and multiply
   C. Write an R program to print Fibonacci sequence
4. A. Write an R program to find the multiplication table
   B. Write an R program to check Prime number
5. A. Create the student data frame for the following
   Student_id
   Student_name
   Branch
   Gender

Bloodgroup Print the data frame, structure and summary of the data frame B. Create a vector and calculate mean, median and mode C. Create data set of students scored marks in an internals and plot a bar chat 6. A. Using Bioconductor packages download SRA file and convert into fastq format B. Using R read the fastq file and find out the length, base composition and GC content of the sequence. C. Find the score for the optimal global alignment between any two sequences 7. A. Retrieve a UniProt protein sequence B. Retrieve a list of sequence from UniProt using SeqnR R package 8. Write an R program to make a simple Calculator 9. Programmatically extract the weather data from given web link (* extract 2017 weather data in CSV format) 10. A. Write an R program to find start and stop codons in a DNA sequence B. Write an R program to view a long multiple alignment
Course Outcomes **After completing the course, the students will be able to**
CO1: Understand the basic knowledge of statistical applications in Bioinformatics/Biological data.
CO2: Learning the R commands, integrating the data sets.
CO3: Writing R programs and parsing the data.
CO4: Application of R programming for the complex problems

Reference Books

1.	Beginning R: The statistical programming language. Mark. Gardener. 2015. Wiley. 987-81-265-4120-1
2.	A little book of R for Bioinformatics. Avril Coghlan, 2017. Creative Commons Attribution 3.0 License.Wiley- ISBN3-527-31555-1
3.	Efficient R Programming: A Practical Guide to Smarter Programming, Colin Gillespie, Robin Lovelace, "O'Reilly Media, Inc.", 2016, 1491950757, 9781491950753
4.	Learning R Programming, Kun Ren, Packt Publishing Ltd, 2016, 1785880624, 9781785880629

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

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

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

Scheme of Continuous Internal Evaluation (CIE) for Practicals: (50 Marks)

The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.

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

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

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

SEMESTER: I						
ESSENTIALS OF COMPUTATIONAL BIOLOGY (Theory and Practice)						
Course Code	**:**	**18MBI13**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**4:0:1**		**SEE**	**:**	**100+50 Marks**
Hours	**:**	**52L+26P**		**SEE Duration**	**:**	**3+3 Hrs**

Unit – I	**10Hrs**

Statistical approach to DNA and Protein sequence analysis: Introduction, scope and applications of Computational biology. Molecular Biology databases. Analysis of single DNA sequence: shotgun sequencing, DNA modeling, Scanning long repeats, Analysis of patterns and Counting of overlaps. Analysis of Multiple DNA or Protein sequences: Frequency comparisons of two sequences. Simple tests for significant similarity in an alignment. Alignment algorithms for two sequences: Gapped global comparisons and Dynamic programming algorithms, linear gap model for fitting one sequence into another and local alignment.

Unit – II	**11 Hrs**

High Throughput Data Analysis: Introduction Next Generation Sequencing (NGS), NGS Experimental Work Flow, Scope and Applications. NGS Platforms - Illumina Reverse Dye-Terminator, Ion Torrent Semiconductor sequencing and Pacific Biosciences Single Molecule Real-Time Sequencing. NGS Data Analysis; Base calling and quality score, Data Quality Control and Pre-processing, Reads Mapping – Mapping approaches and algorithms, and Tertiary analysis. Computing Needs for NGS – Data storage, transfer, Computing power, Software needs and Bioinformatics Skills. Case study – Genotyping and Genomics Variation Discovery by Whole Genome resequencing.

Unit – III	**10 Hrs**

Molecular Modelling and Simulation: Introduction to Molecular Modelling and Simulation; brief introduction to protein structure hierarchy, structural databases, and Force fields. Modelling applications – prediction of secondary structure of Protein and RNA, Prediction of 3D structure of Proteins, Prediction of Binding pockets, pocket analysis and Molecular docking – algorithms involved. Application of Simulation – Modelling and simulation of Permeation events, membrane dynamics and protein dynamics. Case studies of modelling and simulation – simulation of Water permeation and Fludic nature of membrane.

Unit – IV	**10 Hrs**

Computational Biology and Cancer research: Mathematical modelling of tumorigenesis - Cellular automaton, tumor, angiogenesis. One hit and two hit stochastic models - Tumour suppressor gene, Kolmogorov forward equation, and retinoblastoma. Microsatellite and chromosomal instability in sporadic - APC gene, colorectal cancer, point mutation. Chromosome loss. Basic models of tumour inhibition and promotion - Metastatic, Angiogenictumor cells, Angiogenesis inhibition. Mechanisms of tumour neovascularization - vasculogenesis, Cancer and Immune responses - Dendritic cell vaccination, Viruses as antitumor weapons - Tumour load, Viral replication and Oncolytic viruses.

Unit – V	**11 Hrs**

Computational Immunology: Overview of immune system**,** Introduction to computational immunology Immunological databases – IMGT – IMGT-GENE-DB, – IMGT-HLA, Tools for the prediction binding affinity between peptide : TAP:MHC:TCR- MHC: Peptide Binding Prediction - SYFPEITHI, BIMAS, MHC PRED, - Future of computational modelling and prediction systems in clinical immunology -overview of models- models for HIV infection.

Unit – VI	**26 Hrs**

1. A. Fetching of DNA, RNA, and Protein sequences from GenBank, PDB, EML, DDBJ and SwissProt and navigation of NGS data.

   B. Retrieving of Structure of Macromolecules and Micromolecules from PDB, Kegg Drug and Pubchem compound and Navigation of Molecular structures.
2. Prediction of 3D structure of unknown sequence using Homology, *ab initio* and Threading.

3. *A. de novo* Genome assembly of unknown genome.
   B. Differential gene expression analysis using transcriptomic data
4. Network analysis using transcriptome data
5. Chip-Seq Analysis.
   A. QTL analysis
   B.Identification of promotor sequences in the whole genome data
6. Design and Molecular Interaction studies of novel ligands with suitable target using Molecular Docking.
7. Modelling and Simulation of Water permeation through Carbon Nanopores.
8. Modelling and Simulation of Membrane Dynamics.
9. Prediction of Peptide binding sites in Unknown Antigenic peptide.
10. Prediction of Genomic alterations in Cancer genome using Whole Genome Sequencing.

Course Outcomes
After completing the course, the students will be able to

CO1: Explain conceptually Sequence, Protein Structure Hierarchy, Physical and Virtual mapping of 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.	Xinkun Wang, "Next-Generation Sequencing Data Analysis", CRC Press, 2016, ISBN 9781482217896
2.	Tamar Schlick, "Molecular Modelling and Simulation: An interdisciplinary discipline", Springer, 2nd edition, 2010, ISBN 9781441963505
3.	Darren Flower, Jon Timmis, "In Silico Immunology", Springer Link, 2007, ISBN: 978-0-387-39238-7
4.	Dominik Wodarz, Natalia Komarova, "Computational Biology of Cancer: Lecture Notes and Mathematical Modeling", World Scientific, 2005, ISBN 9789814481878

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Theory (100 Marks) + Practical (50 Marks) = Total Marks (150)

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

SEMESTER: I						
DATA STRUCTURES USING PYTHON (Group A: Professional Elective)						
Course Code	**:**	**18MBI1A1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3Hrs**

Unit – I	**07 Hrs**
Python basics: Introduction to python and python programming**.** Data types, Operators and Statements. Object oriented programming in Python. Exception handling.	
Unit – II	**08 Hrs**
Asymptotic analysis: Introduction to Algorithm analysis. Asymptotic notations – "*Big-oh"* and related notations. Comparative Analysis. Examples of Algorithm Analysis – Bubble sort, Insertion sort, Merge sort, Selection sort, Shell sort, Divide-and-Conquer sorting, Merge sort and radix sort. **Recursion:** Introduction to recursion. Examples of recursion – Factorial function, Fibonacci series, Divide and Conquer (Towers of Hanoi) and Binary search.	
Unit – III	**08 Hrs**
Stacks: Lists and Arrays. Reversing a list, Information hiding, Implementation of Stacks - Simple Array-Based Stack Implementation. Pushing, Popping, and Other Methods. Analysis of Stack implementation. Reversing Data Using a Stack.**Queues:** Definitions, Queue Operations, Implementations of Queues – Array based Implementation of Queues. Double-Ended Queues - Implementing a Deque with a Circular Array. **Linked lists:** Introduction to linked lists. Types – Singly linked, Circular linked, Doubly linked and Doubly linked circular lists. Implementation of these types.	
Unit – IV	**08 Hrs**
Trees: Introduction to trees - Tree definitions and properties, types of tree. General Trees and Binary trees. The binary tree abstract data type. Implementing trees – Linked structure for General and Binary trees. Array based representation of Binary tree. Tree traversal, traversal algorithms – preorder and postorder traversals of General Trees, Breadth-First Tree Traversal, and Inorder Traversal of a Binary Tree. Implementing Tree Traversals in Python. **Heaps and Priority Queues:** Heap Data Structure. Implementing a Priority Queue with a Heap. Python Heap Implementation. Analysis of a Heap-Based Priority Queue. Bottom-Up Heap Construction. Heap sort.	
Unit – V	**08 Hrs**
Maps, Hash Tables, and Skip Lists: Introduction to Map Abstract data type and MapBase class. Implementation of Unsorted and Sorted Map. Hash tables – Has functions, Collision-Handling Schemes - Separate Chaining, Open Addressing, and Linear Probing. Load Factors, Rehashing, and Efficiency. Implementation of Hash table in python. Skip Lists - Search and Update Operations in a Skip List. Sets, Multisets, and Multimaps - Implementing Sets, Multisets, and Multimaps in python. Search Trees: Binary Search Trees – Navigation, searching, insertion and deletions in Binary Search tree and Implementation in Python. Balanced Search Trees, AVL trees, splay trees, (2,4) trees and Red-Black trees and their implementation.	
Course Outcomes **After completing the course, the students 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 which is the model for the research.	
CO4: Analyse dynamic models and regulatory networks at cellular level	

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

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

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

SEMESTER: I						
GENOMICS AND PROTEOMICS (Group A: Professional Elective)						
Course Code	**:**	**18MBI1A2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3Hrs**

Unit – I	**08 Hrs**

Introduction to Genomics: Genome evolution and organization in prokaryotes and eukaryotes, Genome mapping: Genetic and physical mapping. Molecular markers and protein markers, Genome sequencing, basics, strategies and methodology. Comparative and Functional genomics; Model systems- Arabidopsis, Human, Drophila and *E coli*. Serial analysis of gene expression (SAGE) and targeting induced local lesions in genome (TILLING). Genome Wide Association Studies (GWAS).

Unit – II	**08 Hrs**

Tools for Genomics: Computational analysis of sequences- finding genes and regulatory regions; Gene annotation; Alignment statistics; Prediction of gene function using homology, context, structures. Expression sequence tags (ESTs), Microarrays technology- Principles and applications, FISH, transcriptome analysis and SNPs determination. Allele mining and single nucteotide polymorphisms (SNPs).Transcriptomics; Cancer Genomics, Epigenomics, Chemical Genomics; Metabolomics, Nutrigenomics, interactomics, Metagenomics. Personal Genomics; Social, Legal and Ethical Implications of Human Genome Research.

Unit – III	**07 Hrs**

Introduction and Scope of Proteomics: Protein separation techniques: Ion exchange, Size exclusion and affinity chromatographic techniques, Poly acrylamide gel electrophoresis, isoelectric focusing, two dimensional poly acrylamide gel electrophoresis, Mass spectrometry based techniques for protein identification.

Unit – IV	**08 Hrs**

Protein Sequencing: 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 – V	**08 Hrs**

Genetic Circuits : Scope, Concepts and Applications, Current Progress in Static and Dyanamic Modelling of Biological networkds, Models and Modeling in Genertic 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.

Course Outcomes

After completing the course, the students 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 which is the model for the research

CO4: Analyze dynamic models and regulatory networks at cellular level

Reference Books

1.	Sangdun Choi. Systems Biology for Signaling Networks, Publisher-Springer, New

	York,2010. ISBN 978-1-4419-5796-2
2.	Andres Kriete, Roland Eils. Computational Systems Biology: From Molecular Mechanisms to Disease:, 2nd Edition , Academic Press, 2013. ISBN 978-0-12-405926-9
3.	Edda Klipp, Ralf Herwig, Axel Kowald, ChristophWierling, Hans Lehrach Systems biology in practice: concepts, implementation and application, Wiley-VCH Verlag GmbH &Co.KGaA,Weinhein 2005.ISBN 978-3-527-31078-4
4.	Glenn Rowe. Theoretical Models in Biology, Oxford University Press – Publisher,Oxford 1994. ISBN 0 19 859687 1.

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

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

SEMESTER: I						
SHELL SCRIPTING **(Group A: Professional Elective)**						
Course Code	**:**	**18MBT1A3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3Hrs**

Unit – I	**07 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	**08 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 completing the course, the students will be able to**	
CO1: Eexplainand 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.	Harry Harvey, Shell Scripting: Learn Linux Shell Programming Step-By-Step (Bash Scripting, Unix), CreateSpace Independent Publishing Platform, 2017.
2.	Steve Parker, “Shell Scripting: Expert Recipes for Linux, Bash, and mor”, John Wiley and Sons, 2011.
3.	Robert Collins, “Shell Programming and Bash Scripting: Ultimate Beginners Guide Book”, CreateSpace Independent Publishing Platform, 2016.
4.	RöbbeWünschiers, Computational Biology: Unix/Linux, Data Processing and Programming, Springer Science & Business Media, 2012.

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

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

SEMESTER: I						
GENE EXPRESSION DATA ANALYSIS & VISUALIZATION (Group B: Professional Elective)						
Course Code	**:**	**18MBI1B1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3Hrs**

Unit – I	**07 Hrs**
Introduction to Genes, RNA and proteins: The genome, gene expressions, functions of genes. RNA, functions of RNA, identification of RNA detection. Principles of network behavior in the Boolean network model: Genetic network, Multigenic& pleiotropic regulation, A simple, binary conceptualization of a biomolecular network. Wiring and rules determine network dynamics.	
Unit – II	**08 Hrs**
Microarray analytics: Robotically spotted DNA microarrays, synthesized oligonucleotide DNA microarrays. Gene expression data: mRNA levels, cDNA microarrays, oligonucleotide chips, RT-PCR, Serial analysis of gene expression, Protein levels, data requirement for gene network interface.	
Unit – III	**08 Hrs**
Analysis of gene expression data: Data quality and processing, unsupervised data analysis, supervised data analysis, survival analysis, combined approaches, interpreting gene expression patterns.	
Unit – IV	**08 Hrs**
Genomic Signal Processing: Introduction, Mathematical models, and modeling DNA Microarray data - Singular Value Decomposition algorithm. Online Analysis of Microarray Data Using Artificial Neural Networks – Introduction, Methods. Signal Processing and the Design of Microarray. Time-Series Experiments.	
Unit – V	**08 Hrs**
Tools and techniques: Use of R package: Preparation of datasets, storage of results, annotation for Entrez Gene Probe Set, Principal Component Analysis, Identification of differentially expressed genes. Clustering analysis.	
Course Outcomes **After completing the course, the students will be able to**	
CO1: Gain knowledge about concepts of gene expression.	
CO2: Learn about tools and techniques used in gene expression analysis.	
CO3: Gain insights into the applications of different tools of gene expressions.	
CO4: Interpret the data sets by developing the concurrent models.	

Reference Books

1.	Russell Deaton, Akira Suyama. DNA Computing: 15th International Meeting on DNA Computing, DNA 15, Fayetteville, AR, USA, June 8-11, 2009. Springer, 2009. ISBN: 978-3-642-10604-0.
2.	Paul F. Predki. Functional Protein Microarrays in Drug Discovery. CRC Press, 2007. ISBN: 978-0-849-39809-4.

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

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

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

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

SEMESTER: I						
RUBY AND BIORUBY **(Group B: Professional Elective)**						
Course Code	**:**	**18MBI1B2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3Hrs**

Unit – I	**07 Hrs**
Ruby basics: Introduction to Ruby, installing and setting up of Ruby environment. Data types, Variables, constants, Arrays & Hashes, Time, Symbols and strings. Operators and statements. Basic math in Ruby. Ruby classes. Regular Expressions.	
Unit – II	**08 Hrs**
Control flow in Ruby: Conditional and Iterators. for, while and Loop control. Functions. Classes – methods, creating and using classes. Exception handling. Working with files. Working with log files.	
Unit – III	**08 Hrs**
Threading and Multithreading: Introduction to parallel and serial programming. Threads and Managing threads. Mutex, fibers and subprocesses.	
Unit – IV	**08 Hrs**
Introduction to BioRuby: Overview of BioRuby. History, Installation and setting up of BioRuby Environment on Linux and Windows. BioGem. Classes and Modules in BioRuby. Usage and Syntax. Using BioPerl and BioPython from BioRuby.	
Unit – V	**08 Hrs**
Bioinformatics and Ruby: Applications of BioRuby in Computational Biology. Biological Databases. Working with sequences and structures. Sequence manipulation, Sequence Input/output and Sequence translation. Fetching and parsing sequences. Sequence Alignments. Sequence and structure mapping. Sequence homology search using fasta and blast – running Blast and Fasta locally and remotely. Parsing existing Alignment Output files. Parsing reference list from PubMed articles. BioSQL and PhyloXML.	

Course Outcomes

After completing the course, the students will be able to

CO1: Understand programming concepts in Ruby and Bioruby

CO2: Apply Ruby programming skills in data science

CO3: Analyze and evaluate the Ruby and Bioruby programming skills in Big Data Science

CO4: Design and implement algorithms related to Homology studies, Searching, Classification, Assembly and Mapping of NGS data

Reference Books

1.	David Thomas, Chad Fowler, Andrew Hunt, "Programming Ruby 1.9 & 2.0: The Pragmatic Programmers' Guide", Pragmatic Bookshelf, 2013.
2.	David Flanagan, Yukihiro Matsumoto, "The Ruby Programming Language: Everything You Need to Know", "O'Reilly Media, Inc.", 2008.
3.	Sandi Metz, "Practical Object-Oriented Design in Ruby: An Agile Primer", Addison-Wesley, 2012.
4.	Jerry Lee Ford, Jr., "Ruby Programming", Cengage Learning, 2010.

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

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

assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

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

SEMESTER: I						
SYSTEMS BIOLOGY (Group B: Professional Elective)						
Course Code	**:**	**18MBT1B3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100 Marks**
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	**08 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	**07 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 completing the course, the students 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 By Andres Kriete, Roland Eils. Academic Press, 2006.
2.	Systems Biology By Andrzej K. Konopka, CRC, 2006.
3.	Gustavo Caetano-Anollés, "Evolutionary Genomics and Systems Biology", John Wiley & Sons, 2011. ISBN-13: 9781118210710
4.	Huma M. Lodhi, Stephen H. Muggleton, "Elements of Computational Systems Biology", John Wiley & Sons, 2010. ISBN-13: 9780470556740

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
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Total CIE is 20+50+30=100 Marks.

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

SEMESTER : 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.	

SEMESTER: II						
BIOPERL AND BIOPYTHON (Theory and Practice)						
Course Code	**:**	**18MBI21**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**4:0:1**		**SEE**	**:**	**100+50 Marks**
Hours	**:**	**52L+26P**		**SEE Duration**	**:**	**3+3 Hrs**

Unit – I	**11Hrs**

Perl: Introduction to Perl, writing and executing a Perl program. Operators, Variables and Special variables. Data Types – Scalar, Array and Associative array. Regular Expressions (REGEX), Components of REGEX - Operators, Metacharacters and Modifiers. Subroutines – types of functions, defining and calling functions in Perl, calling function - call by value and call by reference. Perl Package – writing and calling package. Perl Module – writing and calling module.

Unit – II	**11 Hrs**

BioPerl: Introduction to BioPerl and BioPerl Objects - Brief descriptions, Location objects, Interface objects and Implementation objects. Sequence Representation: Representing large sequences, Representing changing sequences. Accessing Sequence data - Using Bioperl: Accessing sequence data from local and remote databases, Accessing remote databases, Indexing and accessing local databases. Sequence and Alignment format Interconversion - Transforming sequence files, Transforming alignment files. Performing Sequence analysis – Global alignment, Local alignment, Multiple sequence alignment, Parsing BLAST alignment report and Parsing multiple sequence alignment.

Unit – III	**10 Hrs**

Python. Python basics – Variables, Operators, Data types and Assignments. Statements – Input/output statements, flow control - IF…THEN….ELSE, SWITCH, FOR, MAP, FILTER and WHILE, goto statements. Names, Functions and Modules

Unit – IV	**10 Hrs**

Object Oriented Programming in Python: Introduction to object oriented programming in python. Classes and objects. Inheritance, Polymorphism. Constructors and Destructors. Exception handling.

Unit – V	**10 Hrs**

Biopython and Bioinformatics: Parsing DNA data files, Image manipulation, and Sequence analysis - Sequence alignment (pair wise and multiple sequence alignment), Dynamic Programming, Detecting tandem repeats and generating Hidden Marko Models, Simulation of EST Clustering. Data mining - Text mining, Simulating Genetic algorithm. Analysis of Microarray data – Spot finding and Measurement.

Unit – VI	**2 Hrs/Week**

1. Using Perl's REGEX, perform the following
   i) trim the sequences files
   ii) read a bulk of HTML files and strip off the HTML tags, and write the data to new file
   iii) extract all fasta IDs from the given sequence file
   iv) Parse the Atomic and Hetero Atomics sections of the PDB
2. A. Write a Perl program that uses both recursive and non-recursive functions to print the nth value in the Fibonacci sequence.

   B. Write a Perl program that prompts the user for an integer and then prints out all prime numbers up to that integer.
3. Write a Perl program to Implement Needleman and Wunch algorithm
4. A. Write a Python program that prints all real solutions to the quadratic equation ax2 + bx + c = 0. Read in a, b, c and use the quadratic formula. If the discriminant b2-4ac is negative,

display a message stating that there are no real solutions.

B. Write a Python Program to implement inheritance.

C. Design, Write and Execute Python Program to calculate the area of triangle and rectangle by using abstract class.

5. A. Design, Write and Execute Python Program that illustrate Exception Handling

   B. Write a Python program that displays the number of characters, lines and words in a text file.

6. Write a Program to construct the Phylogenetic tree using sequential clustering by reading input distance matrix.

7. Write a Python program to implement Client Server(Client requests a file, Server responds to client with contents of that file which is then display on the screen by Client – Socket Programming)
8. Write a program to insert Protein information into ProteinDB database and retrieve the list of Protein sequences based on particular queries
9. Create a sideshow which has three slides. Which includes only text, program should change to the new slide after 5 seconds. After the third slide program returns to the First Slide
10. Create a sideshow which has three slides, which includes pictures at PNG format. Program should change to the new slide other 5 seconds.

Course Outcomes
After completing the course, the students will be able to

CO1: Define and explain concepts of Object Oriented Programming along with Threading, Event management, Database connectivity as well as Web programming

CO2: Apply Bioperl and Biopython, Database connectivity as well as Web programmingto solve the problems in the area of Big Data Analytics

CO3: Analyze and evaluate programming applications of both Perl and Python with case studies

CO4: Design and implement basic algorithms to perform high throughput data analysis in the field Sequence and structure analysis

Reference Books

1.	**Perl Programming for Biologists** by D. Curtis Jamison, Wiley-IEEE, 2003.
2.	**Beginning Perl for Bioinformatics** by James Tisdall, O'Reilly, 1st Edition, 2001
3.	**Bioinformatics Programming Using Python** by Mitchell L Model, O'Reilly Media, Inc., 2009.
4.	**Python for bioinformatics** by Jason M. Kinser, Jones & Bartlett Learning, 2009.

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

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

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

Scheme of Continuous Internal Evaluation (CIE) for Practicals: (50 Marks)
The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.

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

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

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

SEMESTER: II						
BIO-MOLECULAR MODELING AND SIMULATION						
Course Code	**:**	**18MBI22**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**4:0:0**		**SEE**	**:**	**100Marks**
Hours	**:**	**52L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**10 Hrs**

Biomolecular Structure and Modelling: Historical Perspective, Introduction to Molecular Modelling, Roots of Molecular modelling in Molecular mechanics. Structure Hierarchy: Helices – Classic α-Helix and π Helices, Left-Handed α-Helix and Collagen Helix. β-Sheets - Turns and Loops. Super secondary and Tertiary structure. Complex 3D Networks. Introduction to X-Ray crystallography and NMR spectroscopy. Introduction to PDB and 3D Structure data, Structure of PDB and other 3D Structure record. Classes in Protein Architecture – Folds, α-Class, Bundles, Folded leaves, Hairpin arrays. β-Class folds, Anti-parallel β domains, parallel and Anti-parallel Combinations. α/β and α+β-Class, α/β Barrels, Open twisted α/β folds, Leucine-rich α/β folds. α+β folds. Quaternary structure.

Unit – II	**11 Hrs**

Force Fields: Formulation of the Model and Energy, Quantifying Characteristic Motions, Complex Biomolecular Spectra, Spectra as force constant sources, In-Plane and Out-of-Plane Bending. Bond Length Potentials, Bond Angle Potentials, Cross bond stretch / Angle bend terms. Torsional potentials, Improper torsion, Cross dihedral/Bond angle, Dihedral terms. Van der Waals potentials. Rapidly decaying potential. Coulomb potential, Slowly decaying potential, Dielectric function and Partial charges. 3D QSAR Methods. Free energy calculations in Biological Systems - Drug design, Signal transduction, Peptide folding, Membrane protein association, Numerical methods for calculating the potential of mean force, Replica-Exchange-Based Free-Energy Methods.

Unit – III	**11 Hrs**

Molecular modelling: Modelling basics. Generation of 3D Coordinates Crystal data, Fragment libraries, and conversion of 2D Structural data into 3D form. Force fields and Geometry optimization. Energy minimizing procedures - Use of Charges, Solvent effects and Quantum Mechanical methods. Computational tools for Molecular modelling. Methods of Conformational analysis - Systematic search procedures, Monte Carlo and molecular dynamics methods.

Unit – IV	**10 Hrs**

Dynamical and Stochastic-Dynamical Foundations for Macromolecular Modelling: Bimolecular sampling: Algorithms, Test molecules, and metrics. Approach to thermal equilibrium in Biomolecular simulation, Hybrid Monte Carlo and Newton Raphson methods. Langevin equation for generalized coordinates, Meta stability and Dominant Eigen values of Transfer operators. Implicit solvent electrostatics in Biomolecular Simulation, New distributed multipole methods.

Unit – V	**10 Hrs**

Quantum-Chemical Models for Macromolecular Simulation: Fast and Reliable Quantum Chemical Modeling of Macromolecules, Quantum chemistry simulations of Glycopeptide antibiotics. **Membrane Protein Simulations:** Membrane proteins and their importance, Membrane protein environments in Vivo and in Vitro. Modeling a complex environment - Simulation methods for membranes, Membrane protein systems, Complex solvents, Detergent micelles, Lipid bilayers, Self-Assembly and Complex systems. Modeling and Simulation of Allosteric regulation in enzymes – Modeling and Simulation of sGC.

Course Outcomes

After completing the course, the students will be able to

CO1: Define and explain concepts of ObjectOriented Programming along with the possible data structures

CO2: Apply Object Oriented programming and data structures to solve the problems in the area of Big Data Analytics

CO3: Analyse and evaluate both set of sorting and searching algorithms with case studies **CO4:** Design and implement algorithms to perform high throughput data analysis in the field Sequence and structure analysis	
Reference Books	
1.	Tamar Schlick. Molecular Modeling and Simulation: An Interdisciplinary Guide, Published by Springer, 2nd edition, 2010.
2.	IsidoreRigoutsos, G. Stephanopoulos. Systems Biology, Published by Oxford University Press US, 2006.
3.	Timothy J. Barth, Michael Griebel, David E.Keyes, Risto M. Nieminen, Dirk Roose, Tamar Schlick. New Algorithms for Macromolecular Simulation, Published by Springer, 2006.
4.	Peter T. Cummings, Phillip R. Westmorland, Brice Carnahan. Foundations of Molecular Modeling and Simulation, Published by American Institute of Chemical Engineers, 2001.

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

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

SEMESTER: II						
RESEARCH METHODOLOGY (Common to all programs)						
Course Code	**:**	**18IEM23**		**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,

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

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

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

SEMESTER : II						
MINOR PROJECT						
Course Code	**:**	**18MB124**		**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%

SEMESTER: II						
ALGORITHM DESIGN AND ANALYSIS **(Group C: Professional Elective)**						
Course Code	**:**	**18MBI2C1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**07 Hrs**
Over view of algorithm design and analysis: Introduction, Algorithms, study of algorithms, role of algorithms, designing algorithms, analysis of algorithms and Applications. **Design of an efficient algorithm:** Introduction to data structures; lists, queues, and stacks. Set representations, Graphs, trees, recursion, divide-and-conquer, balancing, dynamic programming and epilogue.	
Unit – II	**08 Hrs**
Study of Algorithm: Phase of study of algorithms; design, anlyse, validation and testing. Writing an algorithm – rules used in writing algorithm, few examples. Algorithm design; steps involved in algorithm design – understanding problem, decision making, specification of algorithm, algorithmic verification, analysis of algorithm, implementation. Performance analysis. Space and time complexity, time space tradeoff, asymptotic notations, properties of Big O notation, and conditional asymptotic notations, recurrence equations, recurrence equations and solving recurrence equations, methods. Analysis of Linear search and insertion sort and mathematical analysis of the linear search and insertion sort.	
Unit – III	**08 Hrs**
Greedy method: Introduction, job sequencing with deadlines, knapsack problem, Minimum cost spanning trees, Single source shortest path and Hafman coding algorithm. **Data structures used in algorithms:** Fundamental operations on sets, hashing, Binery search, binary search trees, optimal binary search tree, tree structures for the UNION-FIND Problem and UNION-FIND algorithm. Balanced tree schemes, Dictionaries and priority ques. Mergeble heaps, concatenable queues and portioning.	
Unit – IV	**08 Hrs**
Algorithms on Graphs: Minimum cost spanning tree, Depth first search, Biconnectivity, strong connectivity, path finding problems. Transitive closure and shortest path algorithms, path problems and matrix multiplication. Algorithms for Fast Fourier Transform (FFT). Discrete Fourier transform and its inverse, the FFT algorithms, FFT using bit operations, product of polynomials, **Integer and polynomial arithmetic:** Similarity between integers and polynomials, multiplication and division and modular arithmetic. Modular polynomial arithmetic and polynomial evaluation. Greatest Common Divisors and Euclid's algorithm. Integer GCD and sparse polynomials.	
Unit – V	**08 Hrs**
Pattern matching algorithm: Finite automate and regular expressions, recognition of regular expressions and substring recognition, 2-Way pushdown automata, position trees and substring identifiers. **Branch and Bound:** Assignment problem, travelling sales man problem and 0/1 Knapsak problem. **NP Complete Problems:** Nondeterministic turing machines, classes P and NP, languages and problems, polynomial space bounded problems and cook's thermo.	
Course Outcomes **After completing the course, the students will be able to**	
CO1: Explain basics of algorithm design and design principles	
CO2: Apply algorithm design principles and potential algorithms in the field of Biological data analytics and Structural Bioinformatics	
CO3: Analyze and evaluate advanced tools used for algorithm design and development in the field of	

Biological data analytics and Structural Bioinformatics	
CO4: Design and development of mind crunching algorithms in the field Biotechnology and Computational biology	
Reference Books	
1.	Parag H. Dave, "Design and Analysis of Algorithms", Pearson Education India, 2009. ISBN-13: 9788177585957
2.	Harsh Bhasin, "Algorithms: Design and Analysis", Oxford University Press, 2015. ISBN-13: 9780199456666
3.	Dexter C. Kozen, "The Design and Analysis of Algorithms", Springer Science & Business Media, 2012. ISBN-13: 9781461244004
4.	KayhanErciyes, "Distributed and Sequential Algorithms for Bioinformatics", Springer, 2015. ISBN-13: 9783319249667

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

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

SEMESTER: II						
ANDROID PROGRAMMING **(Group C: Professional Elective)**						
Course Code	**:**	**18MBI2C2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**07 Hrs**

Introduction to Java: Java and Java applications. Java Development Kit (JDK). Byte Code, JVM; Object-oriented programming. Simple Java programs. Data types and Tokens: Boolean variables, int, long, char, operators, arrays, white spaces, literals, assigning values. Creating and destroying objects. Access specifiers. Operators and Expressions. Statements - Input and Output, Control Statements and Jump Statements. **Classes, Inheritance, Exceptions:** Classes in Java, Class name, Super classes, Constructors. Creating instances of class. Inheritance: Simple, multiple, and multilevel inheritance; Overriding, overloading. Exception handling

Unit – II	**08 Hrs**

Multi-Threaded Programming, Event Handling: Multi Programming: Extending threads; Implementing rentable. Synchronization, Changing state of the thread. Bounded buffer problems, Read-write problem, Producer-Consumer problems.

Event Handling: Two event handling mechanisms, Delegation event model, Event classes; Sources of events; Event listener interfaces. Delegation event model; Adapter classes; Inner classes

Unit – III	**08 Hrs**

Introduction to Android: Introduction to Android and its developmental framework. Delvik Virtual Machine (DVM). Setting up of Android development environment. Android developmental tools. Android Asset manager. Applications for android. Activity Manager and their classes. Application Manifest.

Unit – IV	**08 Hrs**

Building Android Applications: Android Layouts, Android UI. Android GUI architecture, Widget tool box. Android menus and other widgets. Intents and processes.

Unit – V	**08 Hrs**

Android multimedia: introduction to Graphics animation and Multimedia bitmaps. Using Audio and Video in android. Using Android file system, Accessing mobile storage, location and maps. GEOCoder, and wake locks. Text to speech. Using camera, brodcaste receivers, Sensor Manager and Bluetooth.

Course Outcomes
After completing the course, the students will be able to

CO1: Understand programming principles in Android for smartphones

CO2: Apply Threading, Event management, Database connectivity as well as Web programming to solve the problems in the area of Big Data Analytics

CO3: Analyse and evaluate efficiency of threading and multithreading with case studies like fetching sequence and structure data from remote web server

CO4: Design and implement basic algorithms based on Dynamic programming and Machine learning for the analysis Biological data

Reference Books

1.	John Horton, "Android Programming for Beginners", Packt Publishing Ltd, 2015. ISBN-13: 9781785889035
2.	Bill Phillips, Chris Stewart, Kristin Marsicano, "Android Programming: The Big Nerd Ranch Guide", Pearson Technology Group, 2017. ISBN-13: 9780134706078
3.	Jeff Friesen, "Learn Java for Android Development: Java 8 and Android 5 Edition", Apress, 2014. ISB-13: 9781430264552

4.	Budi Kurniawan, "Android Application Development: A Beginner's Tutorial", Brainy Software Inc, 2015. ISBN-13: 9780992133016

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

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

SEMESTER: II						
***INSILICO* DRUG DESIGN** **(Group C: Professional Elective)**						
Course Code	**:**	**18MBT2C3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3 Hrs**

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	**07 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	**08 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 completing the course, the students 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: Able to estimate the relevant drug capabilities of known and unknown compounds.

CO4: To equip with the drug design skills and patenting ability and spread awareness about the compounds.

Reference Books	
1.	Cancer Drug Design and Discovery by Stephen Neidle, Academic Press – Publisher,2008.ISBN0123694485, 9780123694485
2.	Bioinformatics Technologies by Yi-Ping Phoebe Chen, Springer Science & Business Media, 2005. ISBN 354026888X, 9783540268888
3.	Textbook of drug design and discovery by 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 byDavid. C. Young, Wiley-Interscience, 2009. ISBN: 978-0-470-12685-1

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

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

SEMESTER: II						
JAVA AND J2EE **(Group D: Professional Elective)**						
Course Code	**:**	**18MBI2D1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**08 Hrs**

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

Unit – II	**08 Hrs**

Multi-Threaded Programming, Event Handling: Multi Programming: Extending threads; Implementing rentable. Synchronization, Changing state of the thread. Bounded buffer problems, Read-write problem, Producer-Consumer problems. Event Handling: Two event handling mechanisms, Delegation event model, Event classes; Sources of events; Event listener interfaces. Delegation event model; Adapter classes; Inner classes.

Unit – III	**08 Hrs**

Applets: The Applet Class: Two types of Applets, Applet basics, Applet Architecture, An Applet skeleton; The HTML APPLET tag; Passing parameters to Applets, Simple Applet display methods; Requesting repainting; Using the Status Window. getDocumentbase() and getCodebase(); ApletContext and showDocument(); The AudioClip Interface; The AppletStub Interface;

Drawing Lines; Drawing Other Stuff; Color; Mouse Input; Keyboard Input and Output to the Console. Threads and Animation, Backbuffers, Graphics and Painting; Clocks. Playing with text: Introduction to 2D arrays and hyperlinks, 3D Graphics - Basic classes.

Unit – IV	**08 Hrs**

Java 2 Enterprise Edition Overview, Database Access: The Concept of JDBC; JDBC Driver Types; JDBC Packages; A Brief Overview of the JDBC process; Database Connection; Associating the JDBC/ODBC Bridge with the Database; Statement Objects; ResultSet; Transaction Processing; Metadata, Data types; Exceptions. Servlets: Background; The Life Cycle of a Servlet; Simple Servlet; The Servlet API. The Javax.servlet Package. Reading Servlet Parameter, Handling HTTP Requests and Responses. Cookies and Session Tracking.

Unit – V	**07 Hrs**

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

Course Outcomes

After completing the course, the students will be able to

CO1: Define and explain concepts of Object Oriented Programming along with Threading, Event management, Database connectivity as well as Web programming

CO2: Apply Threading, Event management, Database connectivity as well as Web programming to solve the problems in the area of Big Data Analytics

CO3: Analyze and evaluate efficiency threading and multithreading with case studies

CO4: Design and implement basic algorithms to perform high throughput data analysis in the field Sequence and structure analysis

Reference Books

1.	Java - The Complete Reference, 9th edition, by Herbert Schildt, McGraw Hill

	Education, 2014. ISBN: 0071808558 ISBN-13: 978-0071808552
2.	Introduction to Java Programming, Comprehensive Version, 10th edition by Y. Daniel Liang, Prentice Hall of India, 2013. ISBN-13: 978-0133761313
3.	BioJava: A Programing Guide by Kaladhar D.S.V.G.K. LAP LAMBERT Academic Publishing 2012 ISBN-13: 978-3659167508
4.	Peter Garst, "Mastering Java through Biology: A Bioinformatics Project Book", Peter Garst, 2014. ISBN-13:9781483534404

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

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

SEMESTER: II						
ARTIFICIAL INTELLIGENCE (Group D: Professional Elective)						
Course Code	**:**	**18MBI2D2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3 Hrs**

Unit – I	**08 Hrs**
Introduction to Artificial Intelligence: Introduction to Artificial Intelligence, Problems, Approaches and tools for Artificial Intelligence. Introduction to search, Search algorithms, Heuristic search methods, Optimal search strategies. Use of graphs in Bioinformatics. Grammers, Languages and Automata. Current Techniques of Artificial Intelligence: Probabilistic approaches: Introduction to probability, Bayes' theorem, Bayesian networks and Markov networks.	
Unit – II	**08 Hrs**
Classification Methods: Linear Classifiers & Logistic Regression, Linear Classifiers, Overfitting & Regularization in Logistic Regression, Decision Trees, Preventing Overfitting in Decision Trees, Handling Missing Data, Clustering and retrieval of data, Nearest Neighbor Search, Clustering with k-means, Hierarchical Clustering.	
Unit – III	**08 Hrs**
Introduction –Agents– Problem formulation– uninformed search strategies – heuristics – informed search strategies – constraint satisfaction. Study of Ethical, legal and social issues associated with AI.	
Unit – IV	**08 Hrs**
Supervised learning (parametric/non-parametric algorithms, support vector machines, kernels, neural networks, Unsupervised learning (clustering, dimensionality reduction, recommender systems, deep learning, Best practices in machine learning (bias/variance theory; innovation process in machine learning and AI, Support vector machines (SVMs), case studies and applications.	
Unit – V	**07 Hrs**
Genetic programming – Method, Applications, Guidelines and Bioinformatics applications. Boolean Networks, Bayesian Networks and Fuzzy Neural Networks with case studies. Learning from observation - Inductive learning – Decision trees – Explanation based learning – Statistical Learning methods - Reinforcement Learning	

Course Outcomes

After completing the course, the students will be able to

CO1: Learn about concepts of artificial intelligence and their applications in Bioinformatics

CO2: Understand the basic ideas and techniques underlying the design of intelligent computer systems

CO3: Use the knowledge acquired for both problem solving and for reasoning.

CO4: Focus on problems, the ethical, legal and social issues involved in the field of AI and use the techniques and algorithms to address those problems.

Reference Books

1.	Intelligent Bioinformatics: The Application of Artificial Intelligence Techniques to Bioinformatics Problems by Edward Keedwell, Ajit Narayanan, published by John Wiley and Sons, 2005. ISBN 9780470021750.
2.	Artificial Intelligence: A Modern Approach by Stuart Jonathan Russell and Peter Norvig. Prentice Hall, 2010. ISBN 0-13-604259-7
3.	Machine Learning Approaches to Bioinformatics by Zheng Rong Yang. World Scientific Publishing Co. Pte. Ltd, 2010.ISBN 981-4287-30-X
4.	Computational Intelligence in Biomedicine and Bioinformatics: Current Trends and Applications. by Tomasz G. Smolinski, Mariofanna G. Milanova, Aboul Ella Hassanien.(Eds.) Published by Springer-Verlag Berlin Heidelberg, 2009.ISBN 978-3-540-

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

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

SEMESTER: II						
HIGH PERFORMANCE BIO-COMPUTING **(Group D: Professional Elective)**						
Course Code	**:**	**18MBT2D3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:1:0**		**SEE**	**:**	**100Marks**
Hours	**:**	**39L+26T**		**SEE Duration**	**:**	**3 Hrs**

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	**07 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	**1 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	**08 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 completing the course, the students 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: Analyze and apply the appropriate tools and techniques to perform high throughput data analysis

CO4: Develop parallel software tools using High Performance Computing

Reference Books

1.	Bioinformatics for High Throughput Sequencing ByNaiara Rodríguez-Ezpeleta, Michael Hackenberg, Ana M. Aransay.| ISBN-13: 9781461407812
2.	Review of "Next-generation DNA sequencing informatics" by 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 by Kevin Autor Dowd, Michael

	KostaLoukides.O'Reilly&Associates, 1993.ISBN 1565920325, 9781565920323

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
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Total CIE is 20+50+30=100 Marks.

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

SEMESTER: II						
BUSINESS ANALYTICS (Global Elective-G01)						
Course Code	**:**	**18CV2G02**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 hrs**

UNIT – I	**07Hrs**

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**

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

UNIT – IV	**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.

Expected 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 Information Services.
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): Total marks: 100
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.

Semester End Evaluation (SEE): Total marks: 100
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 **7 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 **9 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 **9 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 **7 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 **7 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.

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

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

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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 (Group G: Global Elective)						
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	**08 Hrs**
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	Prasanna Chandra, Project Planning Analysis Selection Financing Implementation & Review, Tata McGraw Hill Publication, 8th Edition, 2010, ISBN 0-07-007793-2.
2	Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK Guide), 5th Edition, 2013, ISBN: 978-1-935589-67-9
3	Harold Kerzner, Project Management A System approach to Planning Scheduling & Controlling, John Wiley & Sons Inc., 11th Edition, 2013, ISBN 978-1-118-02227-6.
4	Rory Burke, Project Management – Planning and Controlling Techniques, John Wiley & Sons, 4th Edition, 2004, ISBN: 9812-53-121-1

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

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

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

SEMESTER: II						
ENERGY MANAGEMENT (Group G: Global Elective)						
Course Code	**:**	**18CH2G05**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 hrs**

Unit-I	**08Hrs**
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	**08Hrs**
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	**07Hrs**
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 (CO):

On completion of the course, the student should have acquired the ability 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-Brobbyand 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.

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

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt

innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) Solving innovative problems 2) Seminar/new developments in the related course 3) Laboratory/ field work 4) mini project.
Total CIE is 20+50+30 = 100 marks.

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

SEMESTER: II						
INDUSTRY 4.0 **(Group G: Global Elective)**						
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 way forward. 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	Alasdair Gilchrist, INDUSTRY 4.0 THE INDUSTRIAL INTERNET OF THINGS,Apress Publisher, ISBN-13 (pbk): 978-1-4842-2046-7
2	Alp Ustundag, Emre Cevikcan, Industry 4.0: Managing The Digital Transformation, Springer, 2018 ISBN 978-3-319-57869-9.
3	Ovidiu Vermesan and Peer Friess, Designing the industry - Internet of things connecting the physical, digital and virtual worlds, Rivers Publishers, 2016 ISBN 978-87-93379-81-7
4	Christoph Jan Bartodziej, The concept Industry 4.0- An Empirical Analysis of Technologies and Applications in Production Logistics, Springer Gabler, 2017 ISBN 978-3-6581-6502-4.

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

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

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

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

SEMESTER: II						
ADVANCED MATERIALS (Group G: Global Elective)						
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	Donald R. Askeland, and Pradeep P. Fulay, The Science & Engineering of Materials, 5th Edition, Thomson, 2006, ISBN-13-978-0534553968
2	Gregory L. Timp, Nanotechnologym 1999th Editionmm Springer, 1999 ISBN-13: 978-0387983349
3	Dr. VD Kodgire and Dr. S V Kodgire, Material Science and Metallurgym 42nd Edition 2018, Everest Publishing House ISBN NO: 81 86314 00 8
4	N Bhatnagar, T S Srivatsan, Processing and Fabrication of Advanced Materials, 2008, IK International, ISBN: 978819077702

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

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

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

SEMESTER: II						
COMPOSITE MATERIALS SCIENCE AND ENGINEERING (Common to AS, BT, CH, CV, IM, ME)						
Course Code	**:**	**18CHY2G08**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**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, Particle reinforced 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 – monolithic ceramics – need for CMC – ceramic matrix – various types of ceramic matrix composites- oxide ceramics – non oxide ceramics – Aluminium oxide – silicon nitride – reinforcements – particles- fibres- whiskers. Sintering – Hot pressing – Cold Isostatic Pressing (CIPing) – Hot isostatic pressing (HIPing). Applications of CMC in aerospace, automotive industries- Carbon /carbon composites – advantages of carbon matrix – limitations of carbon matrix carbon fibre – chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique- Processing of Ceramic Matrix composites.

Unit –IV	**08 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 metallurgy process – diffusion bonding – stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface-measurement of interface properties- applications of MMC in aerospace, automotive industries.

Unit –V	**07 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-verlagGmbh, , ISBN: 9780387743646, 0387743642
2	The Science and Engineering of Materials, K Balani, Donald R Askeland,6th Edition-Cengage, Publishers, ISBN: 9788131516416
3	Polymer Science and Technology, Joel R Fried , 2nd Edition, Prentice Hall, ISBN: 9780137039555
4	Nanomaterials and nanocomposites, Rajendra Kumar Goyal , 2nd Edition, CRC Press-Taylor & Francis, ISBN: 9781498761666, 1498761666

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
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Total CIE is 20+50+30=100 Marks.

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

SEMESTER: II						
PHYSICS OF MATERIALS (Group G: Global Elective)						
Course Code	**:**	**18PHY2G09**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**39L**		**SEE Duration**	**:**	**3 hrs**

Unit-I	**07 Hrs**
Crystal Structure : Symmetry elements-seven crystals systems-Reciprocal lattice-Packing fraction, Lattice Vibration-Brillouin zones, Analysis of Crystal structure using XRD, Thermal properties.	
Unit-II	**08 Hrs**
Dielectric Materials: Basic concepts-Langevin's Theory of Polarisation-Clausius-Mossotti Relation-Ferro electricity-Piezoelectricity-Properties of Dielectric in alternating fields-The complex Dielectric Constant and Dielectric Loss, Polarizability as a function of frequency-Complex dielectric constant of non-polar solids-Dipolar relaxation, Applications.	
Unit -III	**08Hrs**
Magnetic Materials : Dia and Paramagnetic materials-Quantum theory of paramagnetic materials-Paramagnetic susceptibility of conduction electrons-Ferro-anti ferromagnetic materials-Superconductors and Applications..	
Unit -IV	**08 Hrs**
Semiconducting Materials Semiconductor-Direct and Indirect bonding characteristics-Importance of Quantum confinement-quantum wires and dots-Ferro electric semiconductors-applications-Polymer semiconductors-Photo conductive polymers, Applications.	
Unit -V	**08 Hrs**
Novel Materials Smart materials-shape memory alloys-shape memory effects-Martensitia Transformation functional properties-processing-texture and its nature.	
Course Outcomes (CO's):	
CO1: Analyse crystals using XRD technique. CO2: Explain Dielectric and magnetic materials. CO3:Integrate knowledge of various types of advanced engineering Materials. CO4: Use materials for novel applications.	
Reference Books:	

1.	Solid State Physics, S O Pillai, 6th Edition, New Age International Publishers, ISBN 10-8122436978.
2.	Introduction to Solid State Physics, C.Kittel, 7th Edition, 2003, John Wiley & Sons, ISBN 9971-51-180.
3.	Material Science, Rajendran V and Marikani, 1stEdition, Tata McGraw Hill, ISBN 10-0071328971.
4.	The Science and Engineering of Materials, Askeland, Fulay, Wright, Balanai, 6th Edition, Cengage Learning, ISBN-13:978-0-495-66802-2.

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

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and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) Solving innovative problems 2) Seminar/new developments in the related course 3) Laboratory/ field work 4) mini project.
Total CIE is 20+50+30 = 100 marks.

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

SEMESTER: II						
ADVANCED STATISTICAL METHODS (Group G: Global Elective)						
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:

Random numbers, Concepts of random sampling from finite and infinite populations, Simple random sampling (with replacement and without replacement). Expectation and standard error of sample mean and proportion.

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, Properties of maximum likelihood estimator (no proofs), Confidence intervals-population mean (large sample), population proportion.

Unit -III	**08Hrs**

Tests of Hypothesis:

Principles of Statistical Inference, Formulation of the problems with examples, Simple and composite hypothesis, Null and alternative hypothesis, Tests - type I and type II error, Testing of mean and variance of normal population (one sample and two samples), Chi squared test for goodness of fit.

Unit -IV	**08 Hrs**

Linear Statistical Models:

Definition of linear model and types, Oneway ANOVA and two way ANOVA models-one observation per cell, multiple but equal number of observation per cell.

Unit -V	**08 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 (CO's):

On completion of the course, the student should have acquired the ability to

CO1: Identify and interpret the fundamental concepts of sampling techniques, estimates and types, hypothesis, linear statistical models and linear regression arising in various fields engineering.
CO2: Apply the knowledge and skills of simple random sampling, estimation, null and alternative hypotheses, errors,one way ANOVA, linear and multiple linear regressions.
CO3: Analyze the physical problem to establish statistical/mathematical model and use appropriate statistical methods to solve and optimize the solution.
CO4: Distinguish the overall mathematical knowledge gained to demonstrate the problems of sampling techniques, estimation, tests of hypothesis, regression and statistical model arising in many practical situations.

Reference Books:

1	Fundamentals of Statistics (Vol. I and Vol. II), 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, John Wiley & Sons, Inc., 3rd Edition, 2003,

	ISBN 0-471-20454-4.
3	S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistic, D. C. Montgomery and G. C. Runger, 10th Edition, 2000, A Modern Approach, 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.

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.

SYLLABUS
FOR
SEMESTER III & IV

SEMESTER: III						
NEXT GENERATION SEQUENCING TECHNOLOGY (Theory and Practice)						
Course Code	**:**	**18MBI31**		**CIE**	**:**	**100+50 Marks**
Credits: L:T:P	**:**	**4:0:1**		**SEE**	**:**	**100+50 Marks**
Hours	**:**	**52L+26P**		**SEE Duration**	**:**	**3Hrs +3Hrs**

Unit – I	**10Hrs**

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	**10 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	**10 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	**11 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.

Unit – VI (Lab component)	**26 Hrs**

1. A. Basics of Linux setup and package installation using Linux terminal
   B. Handling NGS Data file formats using FastQC
2. A. Metagenome sequence analysis
   B. 16s rRNA analysis
3. Whole genome sequencing analysis assembly and annotation
4. Transcriptome sequence analysis
5. Differential gene expression analysis using transcriptomic data
6. Network analysis using transcriptome data
7. A. Chipseq data analysis
   B. Small RNA analysis

8. Simulating NGS data 9. A. Phylogenetic data analysis B. Genome proteome mapping 10. A. Identification of promotor sequences in the whole genome data B. QTL analysis
Course Outcomes **After completing the course, the students will be able to**
CO1: Understand the basic knowledge of Next Generation Sequencing
CO2: Analyse 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: 9781936113873.
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:-13:9781617790881
4.	Clinical Applications for Next-Generation Sequencing by UrszulaDemkow and RafalPloski:Academic Press, 2015, ISBN-13: 9780128017395

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) minor project.
Total CIE(Q+T+A) 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):
Theory (100 Marks) + Practical (50 Marks) =Total Marks (150)

SEMESTER: III						
INTERNSHIP						
Course Code	**:**	**18MBI32**		**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 sustainabilitypresentation skills and report writing	55%

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

SEMESTER: III						
MAJOR PROJECT : PHASE-I						
Course Code	**:**	**18MBI33**		**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 tworeviews. 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 the topic, Literature Survey, Problem Formulationand 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						
ADVANCED DATA SCIENCE (ProfessionalElective-E1)						
Course Code	**:**	**18MBI3E1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**4:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**52L**		**SEE Duration**	**:**	**3Hrs**

Unit – I **11 Hrs**

Introduction

Introduction to data science, big data and data science hype, current landscape of perspectives, population and samples, statistical modelling, probability distribution, fitting a model, exploratory data analysis, data science process.

Unit – II **11 Hrs**

Machine learning algorithms

Linear regression, k-nearest neighbour, k-means, Naïve Bayes algorithm, data wrangling; data cleaning, reshaping, integration, feature generation: brainstorming, role of domain expertise, place of imagination, filters, wrappers, decision trees.

Unit – III **10 Hrs.**

Recommendation systems

Dimensionality reduction, singular value decomposition, mining social networks as graphs, Node level analysis, group level analysis. Data visualization: Basic principles, ideas and tools. Normalization of the data.

Unit – IV **10 Hrs**

Data visualization and predictive analytics

Preparation of the data for visualization, Tableau, Qlick view and D3, Tools and the environment, application of modelling in business models, missing imputations.

Unit – V **10 Hrs**

Data Science and ethical issues

Discussion on privacy, security, ethics, lookback at data science, next generation data scientists.

Course Outcomes

After completing the course, the students will be able to

CO1:Demonstrate the knowledge of specialized statistical methods using Big data.
CO2:Apply the statistical and computational methods using R
CO3:Able to estimate the relevant tests of relativity of the data.
CO4:Interpret the data sets using concurrent statistical methods and tools.

Reference Books:

1.	An Introduction to Statistical Learning with Applications in R,Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani.. Springer, 2013, ISBN 978-1461471370.
2.	Mining of Massive Datasets ,Jure Leskovek, AnandRajaraman and Jerey Ullman.. v2.1, Cambridge University Press, 2014,ISBN 948-1-107-07723-2
3.	Data Mining: Concepts and Techniques ,Jiawei Han, Micheline Kamber and Jian Pei. Third Edition. Morgan Kaufmann Publishers. 2012. ISBN 978-0-12-381479-1.
4.	A Probabilistic Perspective , Kevin P. Murphy. Machine Learning. MIT Press. 2013. ISBN 0262018020.

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) 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
DATA WAREHOUSING AND DATA MINING
(ProfessionalElective-E2)

Course Code	**:**	**18MBI3E2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**4:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**52L**		**SEE Duration**	**:**	**3 Hrs**

Unit – I **10 Hrs**

Introduction to Data Warehousing
Heterogeneous information, integration problem, Warehouse architecture, warehouse vs DBMS. Aggregations: SQL and Aggregations, Aggregation functions and Grouping. Data Warehouse Models and OLAP Operations: Decision support; Data Marts, OLAP vs OLTP. Multi-Dimensional data model. Dimensional Modeling. ROLAP vs MOLAP; Star and snowflake schemas; the MOLAP cube; roll-up, slicing, and pivoting.

Unit – II **11 Hrs**

Issues in Data Warehouse Design: Design issues
Monitoring, Wrappers, Integration, Data cleaning, Data loading, materialized views, Warehouse maintenance, OLAP servers and Metadata. Building Data Warehouses: Conceptual data modelling, Entity-Relationship (ER) modelling and Dimension modelling. Data warehouse design using ER approach. Aspects of building data warehouses.

Unit – III **10 Hrs**

Introducing Data Mining
KDD Process, Problems and Techniques, Data Mining Applications, Prospects for the Technology. CRISP-DM Methodology: Approach, Objectives, Documents, Structure, Binding to Contexts, Phases, Task, and Outputs

Unit – IV **11 Hrs**

Data Mining Inputs and Outputs
Concepts, Instances, Attributes. Kinds ofLearning, Kinds of Attributes and Preparing Inputs. Knowledge representations - Decision tables and Decision trees, Classification rules, Association rules, Regression trees & Model trees and Instance-Level representations.

Unit – V **10 Hrs**

Data Mining Algorithms
One-R, Naïve Bayes Classifier, Decision trees, Decision rules, Association Rules, Regression, K-Nearest Neighbour Classifiers. Evaluating Data Mining Results: Issues in Evaluation; Training and Testing Principles; Error Measures, Holdout, Cross Validation. Comparing Algorithms; Taking costs into account and Trade-Offs in the Confusion Matrix.

Course Outcomes
After completing the course, the students will be able to
CO1:Demonstrate the knowledge of specialized data warehousing methods
CO2:Apply the statistical and computational methods for genome and protein data.
CO3:Able to work with the mining tools to help the decision support system
CO4:Interpret the data sets using concurrent statistical method.

Reference Books:

1.	Data Mining: Introductory and Advanced Topics, Margaret H. Dunham., Pearson Education India, 2006, ISBN-13: 9788177587852
2.	Intelligent Data Warehousing,Zhengxin Chen, CRC Press, 2001, ISBN-13: 978-0849312045
3.	Principles of Data Mining, D. J. Hand, HeikkiMannila, Padhraic Smyth, MIT Press, 2001, ISBN-13: 9780262082907
4.	Kimball's Data Warehouse Toolkit Classics: The Data Warehouse Toolkit, Ralph Kimball, Margy Ross, Bob Becker, Joy Mundy, Warren Thornthwaite, 2nd Edition; Wiley, 2009, ISBN-13: 9780470479575

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) 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
BIG DATA ANALYTICS AND APPLICATIONS
(ProfessionalElective-E3)

Course Code	**:**	**18MBI3E3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**4:0:0**		**SEE**	**:**	**100 Marks**
Hours	**:**	**52L**		**SEE Duration**	**:**	**3Hrs**

Unit – I **11 Hrs**

Introduction to Big Data

Distributed file system – Big Data and its importance, Four Vs, Drivers for Big data, Big data analytics, Big data applications.

NoSQL

Introduction. SQL versus NoSQL,NewSQL, Comparison of SQL, NoSQL and NewSQL. **Data-in Data-out**

Document Metadata, Indexing a document, Retrieving a document. Examples of NoSQL Data in Biology.

Biological databases

Structured, Semi-Structured and Unstructured data. Types of Sequence Databases - The nucleotide and protein sequence databases, Primary and secondary databases. Structure Databases - PDB and MMDB records, molecular modelling databases at NCBI. Special Databases - Genome, Microarray, metabolic pathway, domain databases. Sequence retrieval from the databases.

Unit – II **10 Hrs**

Hadoop Architecture, Hadoop Storage

HDFS, Common Hadoop Shell commands , Anatomy of File Write and Read, NameNode, Secondary NameNode, and DataNode, HadoopMapReduce paradigm, Map and Reduce tasks, Job, Task trackers - Cluster Setup – SSH & Hadoop Configuration – HDFS Administering –Monitoring & Maintenance.

Unit – III **10 Hrs**

Hadoop Ecosystem and Yarn

Hadoop ecosystem components - SPARK, FLUME, Hadoop 2.0 New Features- NameNode High Availability, HDFS Federation, MRv2, YARN.

Unit – IV **11 Hrs**

Real-Time Applications in the Real World

Using HBase for Implementing Real-Time Applications- Using HBase as a Picture Management System Using Specialized Real-Time Hadoop Query Systems Apache Drill, Using Hadoop-Based Event-Processing Systems HFlame, Storm. Using Hbase and Hadoop for implementing real time applications in Life Science: Molecular modelling and Molecular dynamics studies - VMD & NAMD. NGS data analysis using Hadoop - Hadoop-BAM, and SeqPig.

Unit – V **10 Hrs**

Hive and Hiveql, Hbase

Hive Architecture and Installation, Comparison with Traditional Database, HiveQL - Querying Data - Sorting And Aggregating. HBase concepts- Advanced Usage, Schema Design, Advance Indexing - PIG, Zookeeper - how it helps in monitoring a cluster, HBase uses Zookeeper and how to Build Applications with Zookeeper

Course Outcomes:

After completing the course, the students will be able to

CO1:Understand fundamentals of Big Data Science, NoSQL,NeqSQL, Hadoop, Yarn, Hive and Hbase

CO2:Describe architecture of NoSQL, NewSQL, HDFS, Hive and HiveQL for high performance computing systems and demonstrate the Analytical ability in data science

CO3:Analyze and apply the appropriate tools and techniques to perform high throughput data analysis

CO4:Design and Execute protocols related to Big Data Analytics for Biology.

Reference Books:	
1.	Big Data Analytics in Bioinformatics and Healthcare,Wang, Baoying, IGI Global, 2014. ISBN-13: 9781466666122
2.	Hadoop Essentials, Shiva Achari, Packt Publishing Ltd, 2015. ISBN-13: 9781784390464
3.	Data Analytics with Hadoop: An Introduction for Data Scientists,Benjamin Bengfort, Jenny Kim,O'Reilly Media, Inc., 2016, ISBN-13: 9781491913765
4.	HBase Design Patterns,Mark Kerzner and SujeeManiyam, Packt Publishing Ltd, 2014. ISBN-13: 9781783981052

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of Quizzes (Q), Tests (T) and Assignments (A). A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) 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	**:**	**18MBI41**		**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 threereviews. 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	Review and refinement of Objectives, Methodology and Implementation	20%
Review-II	Implementation, Testing, Verification and Validation of results, Conclusions and Future Scope of Work	40%
Review-III	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**	
SEEReport 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	**:**	**18MBI42**		**CIE Marks**	**:**	**50**
Credits L:T:P	**:**	**0:0:2**		**SEE Marks**	**:**	**50**
Hours/Week	**:**	**4**		**SEE Duration**	**:**	**30 min**

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 and Associate Professor/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 will be done in batches, not exceeding 6 students per batch.