Savitribai Phule Pune University

(Formerly University of Pune)

THREE Year Degree Program in

Industrial Mathematics with Computer Applications

(Faculty of Science & Technology)

Revised Syllabi for

M.Sc. (Industrial Mathematics with Computer Applications)

(For Department of Mathematics, Savitribai Phule Pune University, Pune-411 007).

Choice Based Credit System Syllabus

To be implemented from Academic Year 2018-2019

(1) **Title** : M. Sc. (Industrial Mathematics with Computer Applications)

(2) **Duration** : Three years (six semester) full time programme

(3) **Total number of credits** : 120

(4) **Preamble of the syllabus**: This program is offered at the Department of Mathematics, Savitribai Phule Pune University. M. Sc. (Industrial Mathematics with Computer Applications) program is of minimum 120 credits in THREE YEARS (six semesters). The objective of the M. Sc.(Industrial Mathematics with Computer Applications) programme is to train the students to meet the challenges of the Software Industry and R&D Sector with mathematical knowledge and computational techniques. This programme is equivalent to M.Sc. (Mathematics), M. Sc. (Computer Science) and M.C.A. (Master of Computer Applications). The structure of the program is as follows:

   (a) In semesters I and II there will be FIVE core courses per semester.

   (b) In semester III there will be four core courses and one elective course to be chosen from module (A)/(B)/(C).

   (c) In semesters IV and V a student should take two core courses and minimum nine elective courses, out of which minimum two courses should be from module (A) and minimum two courses from module (B).

   (d) The last semester VI will be Industrial training/Institutional project (16 credits), which is core.

   (e) For a 4 credit course there will be 4 hours of classroom teaching and and one/two hour(s) of lab work/problem solving session/ tutorial/ related activity per week for fifteen weeks.

(5) **Evaluation Rules** :

   (a) Each course will carry 100 marks except MI-601.

   (b) There will be Continuous Assessment (CA) and End Term Examination (ETE) for each course of 50 marks each.

   (c) For CA , 50% of the marks will be based on tests (minimum 2). In addition, a teacher may consider one or more of the following evaluation options.

      (i) Home Assignment(s)

      (ii) Seminar/Presentation by the student

      (iii) Laboratory assignment/Practical examination

      (iv) Group Discussions

      (v) Research Paper Review

      (vi) Technology Demonstration

(vii) Mini projects in group of maximum 2 members.

(d) For passing a course a student has to earn 30% marks in both CA and ETE separately and minimum 40% marks in the combined grading of the CA and ETE.

(e) If a student fails in a course in any semester then he/she can appear only for the End Term Examination (ETE) of the following semester. However he/she can improve the continuous assessment (CA) performance in any of the forthcoming semesters in which the course is subsequently conducted and in this case, the student will have to appear for the ETE also for the said course.

(f) A student has to complete Industrial Training/Institutional Project in the sixth semester to acquire 16 credits. He/She should obtain a completion certificate (with grade O / A+ / A / B+ / B / C / P / F) from them, which will appeare on the statements of marks. This grade will not be counted for their GPA.

(6) **ATKT Rules** : Student who wishes to take admission to the second/ third year of M.Sc.(Industrial Mathematics with Computer Applications) should have obtained at least 20 credits out of the 40 credits of the First year M.Sc.(Industrial Mathematics with Computer Applications).

(7) **Completion of the Degree Programme** :

(a) In order to pass the M.Sc. (Industrial Mathematics with Computer Applications) course a student has to obtain 120 credit points and complete the audit courses floated by the University time to time.

(b) If a student fails in a course then the said course will not be taken into account for calculating GPA and overall grade. Only thoses courses in which the student has passed will be taken into account for calculating the GPA and overall grade.

(c) The policies and procedures determined by the University will be followed for the conduct of examinations and declaration of the result of the candidate.

(8) The overall course structure is summarized in the table below.

Course Type	**Course(s)**	**Minimum Credits**
Core	Mathematics (07) and Computer (09) Courses	64
Core	Industrial Training / Project	16
Elective	Module (A): Computer Courses (Minimum 02) Module (B): Mathematics Courses (Minimum 02) Module (C): Other Department Courses **(Combination of these three to make minimum (10) Courses)**	40
Total Credits		**120**

(9) Department may introduce additional elective course(s) on recommendations of the Departmental Committee. The syllabus of the elective courses will be prepared by the concerned teacher and will be flexible to accommodate new developments in that area. Whenever such an optional course is floated, the concerned syllabus will be discussed and approved in the Departmental Committee.

(10) **Course Structure :**

Semester I : (Total Credits 20)

Subject Type	**Subject Code**	**Subject Title**	Number of Credits
Core	MI-101	Algebra	4
Core	MI-102	Linear Algebra	4
Core	MI-103	Discrete Mathematics	4
Core	MI-104	Computer Organization /(*)Statistics and Probability	4
Core	MI-105	Programming in C	4

(*) *In force from 2019-2020.*

Semester II : (Total Credits 20)

Subject Type	**Subject Code**	**Subject Title**	Number of Credits
Core	MI-201	Foundations of Analysis	4
Core	MI-202	Differential Equations	4
Core	MI-203	Data Structures	4
Core	MI-204	Programming in C++/(*)Programming with Python	4
Core	MI-205	Operating Systems	4

(*) *In force from 2019-2020.*

Semester III : (Total Credits 20)

Subject Type	**Subject Code**	**Subject Title**	Number of Credits
Core	MI-301	Complex Analysis	4
Core	MI-302	Database management systems	4
Core	MI-303	Theory of Computer Science	4
Core	MI-304	Design and Analysis of Algorithms	4
Elective	from Module (A)/(B)/(C)		4

Semester IV & V : (Minimum Credits 44)

Subject Type	**Subject Code**	**Subject Title**	Number of Credits
Core	MI-401	Software Engineering	4
Core	MI-402	Computer Networks	4
Elective	from Module (A)		8
Elective	from Module (B)		8
Elective	from Module (A)/(B)/(C)		20

Semester VI :(Total Credits 16)

Subject Type	**Subject Code**	**Subject Title**	Number of Credits
Core	MI-601	Industrial Training / Project	16

Module (A): Computer Courses

Subject Code	**Subject Title**	Number of Credits
MI-EC01	Data Mining	4
MI-EC02	Machine Learning	4
MI-EC03	Computer Graphics	4
MI-EC04	Artificial Intelligence	4
MI-EC05	Image Processing	4
MI-EC06	Programming with JAVA	4
MI-EC07	Programming with DOT NET	4
MI-EC08	Cloud Computing	4
MI-EC09	Object Oriented Modeling and Design	4
MI-EC10	Programming using Mobile Technologies	4
MI-EC11	Compiler Construction	4
MI-EC12	Programming with Advanced Java	4
MI-EC13	Quantum Computing	4
MI-EC14	Advanced Databases and NoSQL	4
MI-EC15	Web Technologies	4

Module (B): Mathematics Courses

Subject Code	**Subject Title**	Number of Credits
MI-EM01	Operation Research	4
MI-EM02	Computational Geometry	4
MI-EM03	Cryptography	4
MI-EM04	Statistical Inference	4
MI-EM05	Integral Transforms	4
MI-EM06	Financial Mathematics	4
MI-EM07	Applied Linear Algebra	4
MI-EM08	Differential Geometry	4
MI-EM09	Rings and Fields	4
MI-EM10	Coding Theory	4
MI-EM11	Numerical Analysis	4
MI-EM12	Partial Differential Equations	4
MI-EM13	Bezier Curves and Splines	4

Module (C): Courses form other Department

MI 101: Algebra

(1) **Introduction to Groups:** Symmetries of a Square, The Dihedral Groups, Definition and Examples of Groups, Elementary Properties of Groups.

(2) **Subgroups and Cyclic Groups:** Terminology and Notation, Subgroup Tests, Examples of Subgroups, Properties of Cyclic Groups, Classification of Subgroups of Cyclic Groups, Properties of Cosets, Lagranges Theorem and Consequences.

(3) **Permutation Groups:** Definition and Notation, Cycle Notation, Properties of Permutations, An application of Cosets to Permutation Groups, The Rotation Group of a Cube and a Soccer Ball.

(4) **Group Homomorphism and Isomorphism:** Definition and Examples of Homomorphism, Properties of Homomorphism. Definition and Examples of Isomorphism, Properties of Isomorphism, Cayleys Theorem, The First Isomorphism Theorem, Automorphism.

(5) **External Direct Products:** Definition and Examples, Properties of External Direct Products, The Group of Units Modulo n as an External Direct Product, Applications.

(6) **Normal Subgroups and Factor Groups:** Normal Subgroups, Factor Groups, Applications of Factor Groups, Internal Direct Products.

(7) **Fundamental Theorem of Finite Abelian Groups:**The Fundamental Theorem, The Isomorphism Classes of Abelian Groups.

Reference Books:

- Joseph A. Gallian, Contemporary Abstract Algebra (Fourth Ed.), Narosa, 1999. (Part 2 : Groups)
- P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra (Second Ed.), Cambridge Univ. Press (Indian Ed. 1995).
- I. S. Luthar and I. B. S. Passi, Algebra-Vol. 1: Groups, Narosa, New Delhi, 1996.

MI 102 : Linear Algebra

(1) Gaussian elimination, echelon forms, properties of determinants, complexity of calculatin determinants.

(2) Vector spaces, subspaces, linear independence, basis, dimension, linear transformations.

(3) Orthogonal vectors and subspaces, orthogonal matrices, projections, least squares, orthogonal basis Gram Schmidt.

(4) Eigenvalues and eigenvectors, diagonalisation, Jordan form, difference equations, A^k, Differential equations, and $e^A t$.

(5) Positive definite matrices, maxima, minima, saddle points, singular value decomposition, matrix norms, condition numbers, computation of eigenvalues, iterative methods for $Ax = b$.

Reference Books:

- Linear Algebra and its applications, by Gilbert Strang.
- Linear Algebra and its applications, by David Lay.
- Bist and Sahay, Linear Algebra.

MI 103: Discrete Mathematics

(1) **Order Relations and Structures:** Partially ordered set, Extremal Elements of Partially ordered sets,Lattices, Finite boolean algebras, Functions on boolean algebras, Circuit designs.

(2) **Trees:** Trees,Labeled Trees, Tree Searching, Undirected Trees, Minimal Spanning Trees

(3) **Topics in Graph Theory:** Graph, Euler Paths and Circuits, Hamiltonian Paths and Circuits, Tranport Networks, Matching Problems, Coloring Graphs,

(4) **Combinatorics:** Combination, Permutation, Generating Functions, Odinary and Exponential Generating Functions, Recurrence Relation, Methods of Solution of Recurrence Relatiion , Substitution Method, Characteristic Method, Generating Function Method, Principle of Inclusion and Exclusion.

Reference Books:

- Kolman, Busby, Ross, Discrete Mathematical Structures,Fifth Edition (Pearson Education).
- Purna Chandra Biswal, Discrete Mathematics and Graph Theory, Second Edition (PHI.).
- Alan Tucker, Applied Combinatorics, Fourth Edition (John Willey).

MI 104: Computer Organization

(1) **Overview of Computer Organization:** Introduction, Basic Terms and Notation, Programmer's View, Advantages of High-Level Languages, Why Program in Assembly Language? Architect's View, Implementer's View. The Processor: Pipelining, Memory: Basic

Memory Operations, Byte Ordering, Two Important Memory Design Issues, Input/Output, Historical Perspective, Technological Advances

(2) **Introduction to Digital Logic:** Introduction, Basic Concepts and Building Blocks, Logic Functions, Boolean Algebra, Logic Circuit Design Process, Deriving Logical Expressions from Truth Tables, Simplifying Logical Expressions, Generalized Gates, Multiple Outputs, Implementation Using Other Gates Combinational Circuits: Introduction, Multiplexers and Demultiplexers, Decoders and Encoders, Comparators, Adders, Programmable Logic Devices, Arithmetic and Logic Units Sequential Logic Circuits: Introduction, Clock Signal, Latches, Flip-Flops, Example Sequential Circuits, Sequential Circuit Design

(3) **Processor Organization and Performance:** Introduction, Number of Addresses, Flow of Control, Instruction Set Design Issues, Microprogrammed Control, Performance RISC and CISC processor architectures CISC (case study of Intel Processors) RISC (case study of ARM processors)

(4) **Memory System Design :** Introduction, A Simple Memory Block , Techniques to Connect to a Bus, Building a Memory Block, Building Larger Memories Cache Memory : Introduction , How Cache Memory Works , Why Cache Memory Works, Cache Design Basics

(5) **Virtual Memory:** Introduction, Virtual Memory Concepts, Page Table Organization, Page Table Entries, The Translation Look aside Buffer, Page Table Placement, Inverted Page Table Organization, Segmentation

(6) **Input / Output Organization:** Introduction, Accessing I/O Devices, I/O Data Transfer, Error Detection and Correction, System Buses and their architecture.

(7) **Interrupts:** Introduction, taxonomy of Interrupts, Hardware Interrupts, Software Interrupts, and Exceptions.

Reference Book:

- Computer System Architecture 3 Edition (Paperback), M. Morris Mano, Pearson Education, ISBN-9788131700709
- Computer Architecture and Organization : An Integrated Approach (Paperback), Miles Murdocca, Vincent Heuring, Wiley, ISBN-9788126511983
- Digital Logic and Computer Design 1st Edition (Paperback), M. Morris Mano, Pearson Education, ISBN-9788177584097

- Computer Organization and Design : The Hardware/Software Interface 4 Edition (Paperback), David A. Patterson, John L. Hennessy, , Morgan Kaufmann Publishers, ISBN-9788131222744
- Computer Organization, Design and Architecture,Shiva 0004 Edition (Hardcover), Sajjan G. Shiva,CRC Press, ISBN-9780849304163

MI 104: (*) Statistics and Probability

(1) Introduction to Probability, Sample space, events, probability of an event, additive rules, conditional probability, multiplicative rule, Bayes' rule

(2) Concept of a random variable, discrete probability distribution, continuous probability distribution, joint probability distribution, independent random variables, Chebyshev's theorem.

(3) Mean of a random variable, variance and covariance, means and covariances of linear combinations of random variables.

(4) Some discrete probability distributions: discrete uniform distribution, binomial and multinomial distributions, hypergeometric distribution, negative binomial and geometric distribution, Poisson distribution and Poisson process.

(5) Some continuous probability distributions: continuous uniform distribution, normal distribution, area under the normal curve, applications of the normal distribution, normal approximation to the binomial distribution, gamma and exponential distribution, chi-squared distribution, lognormal distribution.

(6) Functions of random variables, transformations of variables, moments and moment generating functions

(7) Statistical hypothesis: general concepts, testing a statistical hypothesis, use of p values for decision making, tests concerning a singular mean (variance known), confidence interval estimation, tests on a single mean (variance unknown).

Reference Books:

- R. Walpole, R.H. Myers, S.L. Myers, and K. Ye, Probability and Statistics for Engineers and Scientists, (Seventh Edition, Pearson India), 2011.
- S Ross, A first course in probability, (Pearson, ninth edition), 2016.

MI 105: Programming in C

(1) **Introductory Concepts:** Introduction to computer, computer characteristics, types of programming languages, introduction to C.

(2) **C Fundamentals:** The character set, identifier and keywords, data types, constants, variables and arrays, declarations, expressions, statements, symbolic constants.

(3) **Operators and Expressions:** Arithmetic operators, unary operators, relational and logical operators, assignment operators, library functions.

(4) **Data Input and Outputs:** Preliminaries, single character input-getchar() function, single character output-putchar() function, entering input data-scanf() function, writing output data- printf() function, formatted inputoutput-gets() and puts() functions.

(5) **Preparing and Running a Program:** Planning and writing a C Program, compiling and executing the program.

(6) **Control Statements:** Preliminaries, the while statement, the do- while statement, the for statement, nested loops, the if-else statement, the switch statement, the break statement, the continue statement, the comma operator, the goto statement.

(7) **Functions:** A brief overview, defining a function, accessing a function, passing arguments to a function, specifying argument data types, function prototypes, recursion.

(8) **Program Structures:** Storage classes, automatic variables, external variables, static variables, multifile programs, more about library functions.

(9) **Arrays:** Defining an array, processing an array, passing arrays to a function, multidimensional arrays, arrays and strings.

(10) **Pointers:** Fundamentals, pointer declarations, passing pointer to a function, pointer and one dimensional arrays, operations on pointers, pointers and multidimensional arrays, array of pointers, pointer to a function, passing functions to other functions, more about pointer declarations.

(11) **Structures and Unions:** Defining a structure, processing a structure, user-defined data types (typedef), structures and pointers, passing structure to a function, self-referential structures, unions.

(12) **Data Files:** Opening and closing a data file, creating a data file, processing a data file, unformatted data files.

Reference Books:

- Byron S, Gottfried, Programming with C, SchaumsOutline series.

- W. H. Press, S. A. Teukolsky et. al., Numerical recipies in C, The art of Scientific Computing.
- Yashwant Kanetkar, Let us C, BPB Publications.
- Brian W, Kernighan, Dennis M, Ritchie, The C Programming Language, Prentice Hall Publication.

MI 201 : Foundations of Analysis

(1) Limits and continuity, Sequences, Completeness, Compactness, Connectedness, Uniform continuity.

(2) Differentiability in one and several variables, The chain rule, The mean value theorem, Functional relations and implicit functions, Higher order partial derivatives, Taylors theorem, Critical points, Extreme value problems, Vector valued functions and their derivatives.

(3) The implicit function theorem, Curves in the plane, Surfaces and curves in space, Transformations and coordinate systems.

(4) Integration of the line, Integration in higher dimensions, Multiple integrals and iterated integrals, Change of variables for multiple integrals, Functions defined by integrals, Improper integrals.

(5) Arc length and line integrals, Greens theorem, Surface area and surface integrals, Vector derivatives, The divergence theorem, Stokes theorem.

Reference Books:

- Gerald B. Folland, Advanced Calculus, Pearson, 2012.
- C. C. Pugh, Real Mathematical Analysis, Springer, New Delhi, 2004
- N. L. Carothers, Real analysis, Cambridge University Press India, 1999.
- H. Royden, Real Analysis, Third Edition, Prentice Hall of India, 1988.

MI 202 : Differential Equations

(1) **Prerequisites:** Linear equations of the first order.

(2) **Linear equations with constant coefficients :** Second order homogeneous equations, Initial value problems, Linear dependence and independence, Nonhomogeneous equations of n-th order, Algebra of constant coefficients.

(3) **Linear equations with variable coefficients :** Initial value problems, Solutions of the homogeneous equation, Wronskian and linear independence, Reduction of order, Nonhomogeneous equations, Legendre equation.

(4) **Linear Equations with regular singular points :** Euler equation, Second order equation with regular singular points, Exceptional cases, Bessel equation.

(5) **Existence and uniqueness of solutions to first order equations:** Separation of variables, exact equations, Method of successive approximations, Lipschitz condition, Approximation to and uniqueness of solutions.

(6) **Existence and uniqueness of solutions to systems and n-th order equations:** Complex n-dimensional space, Systems as vector equations, Existence and uniqueness of solutions to systems, Existence, Uniqueness for linear systems and equations of order n.

Reference Books:

- E. A. Coddington, An Introduction to Ordinary Differential Equations (Prentice- Hall).
- G. F. Simmons and S. G. Krantz, Differential Equations (Tata McGraw-Hill).

MI 203: Data Structures

(1) **Introduction to Data Structures:** Abstract Data Types, review of arrays and strings, structures and pointers concepts in C/C++, recursion and its efficiency.

(2) **Stacks:** Operations and applications (Infix, Postfix and prefix expression handling),

(3) **Queues:** Operations and applications,

(4) **Circular Queues:** Operations and applications, Concept of Double ended Queue and Priority Queues

(5) **Linked Lists:** Operations and applications of Linear linked list, Circular linked list, Doubly linked list.

(6) **Trees:** Binary Trees, Binary Tree Representations, Operations (insert/delete), Tree Traversal Techniques, Threaded Binary Tree. Applications of Trees, Search Trees: AVL Tree (single and double rotations), B-Trees

(7) **Graphs:** Representation (Matrix/Adjacency) and Traversal (Depth First Search/Breadth First Search), Spanning Trees, Minimal Spanning Tree (Prim's and Kruskalss algoritm), Shortest Paths and All Pair Shortest Path, Dijkstras, Floyd-Warshall Algorithms.

(8) **Hash Table:** Hash Table: Hash Function, Collision and its Resolution, Separate Chaining, Open Addressing (linear probing, quadratic probing, double hashing), Rehashing, Extendible Hashing

(9) **Searching Techniques:** Linear Search, Binary Search (array/ binary tree) methods.

(10) **Sorting Techniques:** General Background, Sorting Techniques: Bubble Sort, Insertion Sort, Selection Sort, Quick sort, Merge sort, Heap sort and Radix Sort

Reference Books:

- ADTs, Data Structures, and Problem Solving with C++, Author: Larry R Nyhoff, ISBN: 9788131764701, Pearson Education
- Data Structures and Algorithms in C++, 2nd Edition Michael T. Goodrich, Roberto Tamassia, David M. Mount, Wiley
- Algorithms and Data Structures: The Basic Toolbox, Mehlhorn, Kurt, Sanders, Peter, Springer, ISBN:9783540779773
- Data Structures Using C and C++ 2 Edition, (Paperback), Yedidyah Langsam, Aaron M. Tenenbaum, Moshe J. Augenstein, PHI Learning ISBN:9788120311770

MI 204: Programming in C++

(1) **Review of C Language:** functions, Pointers, Structures, Array, file handling

(2) **Introduction:** What is object-oriented programming? Why Do We Need Object-Oriented Programming characteristics of Object-Oriented Languages. C++ and C

(3) **C++ Programming Basics:** Output Using cout, Directives. Input With cin. Type bool. The setw Manipulator. Type Conversions.

(4) **Functions:** Returning values From Factions. Reference Arguments, Overloaded Function, Inline Function. Default Arguments. Returning by Reference.

(5) **Object and Classes:** Making sense of core object concepts (Encapsulation Abstraction, Polymorphism, Classes, Massages Association, Interfaces) Implementation of Class in C++, C++ Objects as Physical Object, C++ Object as Data Types Constructor. Object as Function Arguments. The Default Copy Constructor, Returning Object From Function. Structures and Classes. Classes Objects and Memory Static Class Data. Const Data. Const and Classes.

(6) **Arrays and String:** Arrays Fundamentals. Arrays as Class Member Data. Arrays of Object. String. The Standard C++ String Class.

(7) **Operator Overloading:** Overloading Unary Operators. Overloading. Binary Operators. Data Conversion. Pitfalls of Operators Overloading and Conversion. Keywords Explicit and Mutable

(8) **Inheritance:** Concept of Inheritance, Derived Class And Base Class, Derived Class Constructors, Overriding Member Function, Inheritance In The English Distance Class, Class Hierarchies, Inheritance And Graphics Shapes, Public And Private Inheritance, Levels

Of Inheritance, Multiple Inheritance, Ambiguity In Multiple Inheritance, Classes Within Classes, Inheritance And program Development.

(9) **Pointer:** Addresses And pointer, The Address-Of Operator &, Pointer And Arrays, Pointer And Faction, Pointer And C- Types String, Memory Management: New And Delete, Pointers To Objects, Debugging pointers, Virtual Function, Friend Function, Static Function, Assignment and Copy Initialization, This Pointer, Dynamic Type Information.

(10) **Streams and Files:** Streams Classes, Stream Errors. Disk File I/O with Streams, File Pointers, Error Handling In File , I/O File I/O With Member Function, Overloading the Extraction And Insertion Operator, Memory As A Stream Object, Command line Arguments, and Printer Output.

Reference Books:

- C++ Primer Plus, Stephen Prata, Pearson, ISBN 9788131786987,
- Programming in C++, Ashok Kamthane, Pearson, ISBN 9788131791448
- Introduction to Programming with C++, Y. Daniel Liang, Pearson, ISBN 9788131760659,
- The C++ Programming Language, B. Stroustrup Addison-Wesley ISBN 978-0321563842

MI 204: (*)Programming with Python

Introduction, Conditional Statements, Looping, Control Statements, String Manipulation, Lists, Tuple, Dictionaries, Functions, Modules, Input-Output, Exception Handling, OOPs concept, Regular expressions, CGI, Database, Networking, Multithreading, GUI Programming, sending email, web scraping using python.

References Books:

- John V Guttag, Introduction to Computation and Programming Using Python, Prentice Hall of India, 2013.
- R. Nageswara Rao, Core Python Programming, Dreamtech Press, 2016.
- Wesley J. Chun(2006), Core Python Programming - Second Edition, Prentice Hall, 2006.
- Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser(2013), Data Structures and Algorithms in Pyhon, Wiley, 2013.
- Kenneth A. Lambert, Fundamentals of Python First Programs, CENGAGE Publication, 2011.
- Luke Sneeringer, Professional Python, Wiley Inc.,2015.

- Mark Lutz, Learning Python, 3rd Edition, OReilly Media, Inc., 2007.
- Katharine Jarmul & Richard Lawson, Python Web Scraping - Paperback, (Packt Publishing Limited; 2nd Revised edition).

MI 205: Operating Systems

(1) **Basics:** Operating System Functionalities, Types of Operating Systems, Computer Architecture support to Operating Systems

(2) Understanding the System Calls

(3) **Process Management:** Process Scheduling - Uniprocessor scheduling algorithms, Multiprocessor and Real-time scheduling algorithms, Process Synchronization - Peterson's Solution, Bakery Algorithm, Hardware Support to Process Synchronization, Semaphores, Critical Regions, Monitors - Deadlock prevention, deadlock avoidance and Deadlock Detection and Recovery - Bankers Algorithm, Threads

(4) **Memory Management:** Segmentation and space allocation, Basics of linking and loading, Demand Paging, Page replacement algorithms, Analysis of page allocation policies - Working Set

(5) **File Systems:** Contiguous, Sequential and Indexed Allocation, File system interface, File System implementation,

(6) **I/O System:** Disk Scheduling, Device drivers - block and character devices, streams, Character and Block device switch tables

(7) **Protection and Security:** Accessibility and Capability Lists

(8) **Case Study of Unix/Linux Operating System** with reference to Process Management, Memory Management and File Management

Reference Books:

- Operating System Concepts 8 Edition (Paperback), Peter B. Galvin, Abraham Silberschatz, Gerg Gagne,Wiley,ISBN:9788126520510
- Operating Systems, Nutt, , Pearson Education ISBN:9788131723593
- Operating Systems, William Stallings, Pearson, ISBN:9788131725283,
- Operating Systems, Haldar & Aravind, Pearson , ISBN: 9788131715482,
- Understanding the Linux Kernel 3rd Edition (Paperback), Daniel P Bovet, Marco Cesati, O'Reilly, ISBN: 9788184040838
- The Design of the UNIX Operating System (Paperback), Maurice J. Bach, PHI Learning, ISBN-9788120305168

MI 301: Complex Analysis

(1) Definition and geometric interpretation of complex numbers, Square roots, Rational powers of a complex number, Topology of complex plane, Sequences and series.

(2) Concepts of limit and continuity, Stereographic Projection, Sequences and series of functions.

(3) Differentiability and Cauchy-Riemann equations, Harmonic functions, Power series as an analytic function, Exponential and trigonometric functions, Logarithmic functions.

(4) Curves in the complex plane, Properties of complex line integrals, Cauchy- Goursat theorem, Consequences of simply connectivity, Winding number, Homotopy version of Cauchys theorem, Cauchy Integral formula, Moreras theorem, Existence of Harmonic conjugate, Taylors theorem, Zeros of analytic functions, Laurent series.

(5) Principle of conformal mapping, Basic properties of Mbius maps, Fixed points and Mbius maps, Triples to triples under Mbius maps, The cross ration and its Invariance property.

(6) Maximum modulus principle, Schwarzs lemma and its consequences, Liouvilles theorem.

(7) Isolated and non-isolated singularities, Removable singularities, Poles.

Reference Books:

- S. Ponnuswamy, Foundations of Complex Analysis, Narosa Publishing House.
- S. Ponnuswamy and Herb Silverman, Complex Variables with Applications, Birkhäuser.
- John B. Conway, Functions of One Complex Variable, Narosa Publishing house.
- J. W. Brown and Ruel V. Churchill, Complex variables and Applications, McGraw-Hill.

MI 302: Database management systems

(1) Nature of Business Systems and Data Processing.

(2) Data Models, ER Model, ER Diagrams

(3) Database design and normalization.

(4) Introduction to SQL and various constructs

(5) Integrity and Security.

(6) Introduction to XML (unstructured data)

(7) Indexing and Hashing Techniques.

(8) Query processing and optimization, transactions, concurrency control and recovery Introduction to decision support and data analysis, data warehousing and data mining

(9) Information Retrieval.

(10) Introduction to NoSQL e.g. MongoDB,

Important Note: Teacher is supposed to take the practicalsrelated to SQL query writing using any of the open source RDBMS engine e.g. MySQL/PostgreSQL. Some part of evaluation should be reserved for the practical aspects

References Books:

- Stones Richards, Beginning Databe with Poster SQL from Novice to Professionals, Academic Press
- Abraham Silberschatz,Henry F. Korth and S. Sudarshan,Database System Concepts
- Raghu Ramakrishnan, Johannes Gehrke, Database Management Systems
- Ramez Elmasri and Shamkant Navathe, Fundamentals of Database Systems
- Korry Douglas and Susan Douglas, Postgre SQL, (second edition, Sams Publication)

MI 303: Theory of Computer Science

(1) Preliminaries : Symbol, Alphabet, String, Prefix and Suffix of Strings, Sets, Operations on sets, Finite and infinite sets, Russells Paradox, Formal Language Relation, Equivalence Relation,(reflexive, transitive and symmetric closures)Principle of Induction

(2) Regular Languages :Regular Expression: Definition, Examples, and Identities Finite Automata: Concept DFA: Definition and examples NFA: Definition, examples, Language accepted By FA,NFA with ε- moves , Regular Expression to FA: Method and Problems -NFA with ε- moves to NFA, NFA to DFA: Method Problems : Minimization of DFA: Problem using Table Method , Subset Construction for NFA with ε-moves to DFA conversion, Application of FA: Pumping Lemma and Examples Closure Properties: Union, Intersection, -Concatenation, Complement, and Kleene Closure

(3) Context Free Languages -Chomsky Hierarchy -CFG : Definition and examples, Ambiguous Grammar : Concept and Examples Simplification of CFG : Removing Useless Symbols, removing unit productions and removing Nullable symbols: Methods and Problems -Normal Forms : CNF and GNF : Method and Problems - Regular Grammar : Definition ,Equivalence of FA and Regular Grammar

(4) Push Down Automaton : Basic Concept , Definition (DPDA and NPDA)Construction of PDA using empty stack and final State method : Examples using stack method Equivalence between acceptance by final state and Empty stack method and examples Equivalence between PDA and CFG (in GNF): Method and examples Properties of Context

Free Languages Pumping Lemma for CFL : methods and problems, Closure Properties of CFLs(Union, Concatenation, and Kleene Closure : Method and Examples)

(5) Turing Machine -Recursive and recursively enumerable language -Introduction to LBA (Basic Model) and CSG. -Definition of TM, -Design of TM for language recognition, Types of Turing Machine (Multitape TM, Non-Deterministic TM, Universal TM, Restricted TM) Undecidable Problem, Halting Problem of TM Simple Arithmetic Problems on Unary Numbers using TM , RAM model of computation Important Note: The LEX tool on Linux is to be used to address the understanding of the Language and grammar aspects in this course. Few laboratory sessions are expected to be covered. Some marks are to be reserved in Continuous Evaluation/Assessment for the laboratory assignments/work.

References Books:

- Introduction to Automata Theory , Languages ,And Computation (2ndEdition Pearson education) By John E. Hopcroft , Rajeev Motwani, Jeffrey D. Ullman
- An Introduction to Formal Languages and Automata, Peter Linz, Jones & Barlett Student Edition, ISBN: 9789380853284
- Fundamentals of Theory of Computation, Principals and Practice, Greenlaw, Hoover, Elsevier, ISBN:9781558604742
- Introduction to Computer Theory By - Daniel I.A. Cohen (John Wiley & Sons (ASIA) Pvt Ltd. 2ndEdition)
- An Introduction to the Theory of Computer Science Languages & Machine (3rdEdition Pearson education) By Thomas A. Sudkamp
- Introduction to Languages and the theory of Computation By John C.Martin (Tata McGraw Hill Edition,2ndEdition)
- Theory of Computer Science (Automata Languages And Computation By K.L.P. Mishra & N. Chandrasekaran (Prentice Hall India 2ndEdition)

MI 304: Design and Analysis of Algorithms

(1) Mathematical Foundation: Growth Functions, Summations, Recurrences Substitutions, Iterations, Master Methods, Counting and probability.

(2) Sorting :Heap Sort, Quick Sort, Merge Sort, Sorting in linear Time, Medians and Order Statistics.

(3) Dynamic Programming : Matrix chain Multiplication, longest common subsequence, optimal polygon triangularisation.

(4) Greedy Algorithm.

(5) Graphs : Traversals, Topological sort, Minimum spanning trees, single source shortest path, All pair shortest path, Maximum flow problems.

(6) Sorting Networks : Comparision, bitonic sort and merge sort networks.

(7) Parallel Algorithms : CRCW, EREW algorithms efficiency sorting linear system problem, Matrix Operations, Strassens Algorithm and matrix inversion.

(8) FFT :Polynomials DFT, FFT.

(9) Number Theoretic Algorithm : Rabin - Karp, KMP, Bower - Moore algorithms. 1

(10) Geometric Algorithms : Finding convex hall, closes pair of points, linear programming problem.

(11) NP Completeness : P and NP classes, NP completeness and reducibility.

(12) Approximation Algorithms : Vertex cover problem, traveling salesman problem, set covering and subset sum problems.

Reference Books:

- T. H Coreman, Leiserson, Rivest, Introduction to Algorithms .

MI 401: Software Engineering

(1) Concepts of software management, The software crisis, principles of software engineering, programming in the small Vs programming in the large.

(2) Software methodologies/processes, The software life cycle, the waterfall model and variations, introduction to evolutionary and prototyping approaches.

(3) Software measurement, Requirements analysis, requirements.

(4) Solicitation, analysis tools, requirements definition, requirements specification, static and dynamic specifications, requirements review. (just revisited)

(5) Software architecture.

(6) Software design, Design for reuse, design for change, design notations, design evaluation and validation.

(7) Implementation, Programming standards and procedures, modularity, data abstraction, static analysis, unit testing, integration testing, regression testing, tools for testing, fault tolerance.

(8) User considerations, Human factors, usability, internationalization, user interface, documentation, user manuals Documentation, Documentation formats, tools.

(9) Project management, Relationship to life cycle, project planning, project control, project organization, risk management, cost models, configuration management, version control, quality assurance, metrics.

(10) Maintenance, The maintenance problem, the nature of maintenance, planning for maintenance.

(11) Tools and environments for software engineering, role of programming paradigms, process maturity.

(12) Introduction to Capability Maturity Model People Capability Maturity Model.

(13) Software Acquisition Capability Maturity Model Systems Engineering Capability Maturity Model.

(14) IEEE software engineering standards.

Important Note: students who take this course are supposed to work in a group of 2 to 3 and are expected to carry out a minor project (software development) which is absolutely necessary and will be used for continuous evaluation by the respective faculty member teaching this course.

References Books:

- Software Engineering, Ian Sommerville, Addison Wesley, (Note : This is also the preferred textbook for the IEEE Software Engineering Certificate Program.)
- The Engineering of Software, Dick Hamlet, Joe Maybee, Addison Wesley
- Introduction to the Team Software Process, Watts S. Humphrey, Addison Wesley
- Software Engineering A Practitioner's Approach European Adaption, Roger S. Pressman, McGraw Hill
- Software Engineering Theory and Practice, Shari Lawrence Pfleeger, Prentice Hall
- Practical Software measurement, Bob Huges, McGraw Hill
- Human Computer Interaction, Dix, Finlay, Abowd and Beale, Prentice Hall
- Software Project Management, Bob Huges & Mike Cotterell, McGraw Hill

MI 402: Computer Networks

(1) Introduction: Network Hardware, Network Software, Preference Models, Network Standardization.

(2) Physical Layer: Theoretical basis for data communication, Guided Transmission Media, Wireless transmission.

(3) Data Link Layer: Design issues, Error detection and Correction: Type of errors, detection and correction of errors Data Link Control & Protocol: Flow & error control, Stop And Wait ARQ, Go Back -N ARQ, Select Repeat ARQ, HDLC.

(4) The Medium Access Sublayer Channel Allocation Problem, Multiple Access Protocols, Ethernet (Cabling, Encoding) Wireless LANs Bluetooth Architecture, Bluetooth Applications, Data link layer switching: repeaters, hubs, bridges, switches, routers, gateways.

(5) Network Layer: Design issues, Routing algorithms, Congestion control algorithms, quality of service.

(6) Transport Layer: Transport Service, Elements of Transport protocols

(7) Application Layer: DNS, Electronic mail, WWW.

Important Note: Students are expected to implement the algorithms taught in this course using libraries with C language on Linux Platform. Some marks are to be reserved in Continuous Evaluation/Assessment for the laboratory assignments/work.

References Books:

- Computer Networks, 5/e, Andrew S. Tanenbaum, David J Wetherall, Pearson Education

- Computer Networking: A Top-Down Approach, 5/e, James F. Kurose, Keith W. Ross, Pearson Education
- Data Communications and Networking, Forouzan, McGraw-Hill

Module (A): Computer Courses

MI-EC 01: Data Mining

(1) **Introduction to Data Mining:** Basic Data Mining Tasks, DM versus Knowledge Discovery in Databases, Data Mining Issues, Data Mining Metrics, Social Implications of Data Mining, Overview of Applications of Data Mining

(2) **Introduction to Data WarehousingL:** Architecture of DW, OLAP and Data Cubes, Dimensional Data Modeling-star, snowflake schemas, Data Preprocessing Need, Data Cleaning, Data Integration & Transformation, Data Reduction, Machine Learning, Pattern Matching

(3) **Data Mining Techniques:** Frequent item-sets and Association rule mining: Apriori algorithm, Use of sampling for frequent item-set, FP tree algorithm, Graph Mining: Frequent sub-graph mining, Tree mining, Sequence Mining

(4) **Classification & Prediction:** Decision tree learning, Construction, performance, attribute selection Issues: Over-fitting, tree pruning methods, missing values, continuous classes, Classification and Regression Trees (CART), Bayesian Classification, Bayes Theorem, Nave Bayes classifier, Bayesian Networks, Inference, Parameter and structure learning, Linear classifiers, Least squares, logistic, perceptron and SVM classifiers, Prediction, Linear regression, Non-linear regression.

(5) **Accuracy Measures:** Precision, recall, F-measure, confusion matrix, cross-validation, bootstrap.

(6) **Software for data mining and applications of data mining:** R, Weka, Sample applications of data mining.

(7) **Clustering:** k-means, Expectation Maximization (EM) algorithm, Hierarchical clustering, Correlation clustering.

(8) **Brief overview of advanced techniques:** Active learning, Reinforcement learning, Text mining, Graphical models, Web Mining.

References Books:

- Data Mining: Concepts and Techniques, Han, Elsevier
- Margaret H. Dunham, S. Sridhar, Data Mining Introductory and Advanced Topics, Pearson Education
- Tom Mitchell, Machine Learning, McGraw-Hill, 1997

- R.O. Duda, P.E. Hart, D.G. Stork. Pattern Classification. Second edition. John Wiley and Sons, 2000.
- Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer 2006
- Raghu Ramkrishnan, Johannes Gehrke, Database Management Systems, Second Edition, McGraw Hill International
- Ian H. Witten, Eibe Frank Data Mining: Practical Machine Learning Tools and Techniques, Elsevier/(Morgan Kauffman),

MI-EC 02: Machine Learning

(1) Basic definitions, types of learning, hypothesis space and inductive bias, evaluation, cross-validation.

(2) Linear regression, Decision trees, overfitting.

(3) Instance based learning, Feature reduction, Collaborative filtering based recommendation.

(4) Probability and Bayes learning.

(5) Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM.

(6) Neural network: Perceptron, multilayer network, backpropagation, introduction to deep neural network, RNN and LSTM.

(7) Clustering: k-means, adaptive hierarchical clustering, Gaussian mixture model.

References Books:

- Tom Mitchell, Machine Learning. First Edition, McGraw- Hill,(1997). (ISBN 10: 0070428077 ISBN 13: 9780070428072)
- Ethem Alpaydin, Introduction to Machine Learning, Edition 2, The MIT Press.(2009). (ISBN 978-0-262-01243-0)

MI-EC 03: Computer Graphics

(1) **Introduction to Computer graphics :** Introduction to computer graphics & graphics systems, Four components of Computer Graphics Representation, Presentation, Interaction and Transformations, Uses of Computer Graphics, Graphics Primitives Pixel/Point, Raster v/s Vector, RGB color model, intensity, Programming essentials event driven programming, OpenGL library.

(2) **Input devices and Interaction tasks:** Essential Functionalities for Interaction Locator, valuator, pick and choice; Hardware used for interaction Input devices key board, mouse, trackball, tablets, light pen;Basic Interaction tasks Position, Selection

(3) **Presentation and Output devices:** Presentation Graphics - frame buffer, display file, lookup table;Display devices, Random and Raster scan display devices; CRT, Plotters and Printers

(4) Point, Line and Polygon primitives Scan conversions, run length encoding, Line drawing algorithms; DDA algorithm, Bresenhams line algorithm, Circle generation algorithm; Scan converting polygons, fill algorithms, Boundary fill algorithm, flood fill algorithm

(5) **2D Transformations and viewing:** Basic transformations: translation, rotation, scaling; Matrix representations & homogeneous coordinates, Reflection shear; Transformation of points, lines, parallel lines, intersecting lines. Viewing pipeline; Window to viewport coordinate transformation, clipping operations, point clipping, line clipping; Cohen Sutherland algorithm, Midpoint subdivision algorithm, Cyrus beck algorithm; Polygon clipping, Sutherland Hodgman algorithm, Weiler-Atherton Algorithm

(6) **3D transformation & viewing:** 3D transformations, translation, rotation, scaling & other transformations; Rotation about an arbitrary axis in space, reflection throughh an arbitrary plane; general parallel projection transformation; Three dimensional viewing, Parallel and Perspective projections

(7) **Curves and Surfaces:** Polygon meshes, Representing polygons; Parametric curves, Hermite Curves, Bezier curves, B-spline curves

(8) **Hidden surfaces Elimination:** Depth comparison, Z-buffer algorithm, Back face detection; BSP tree method, the Painters algorithm, scan-line algorithm; Hidden line elimination, wire frame methods, fractal geometry; Color & shading models Light & color model; interpolative shading model; Texture

Important Note: Students are expected to implement the algorithms taught in this course using OpenGL/Graphics library with C language on Linux Platform. Some marks are to be reserved in Continuous Evaluation/Assessment for the laboratory assignments/work.

References Books:

- Hearn, Baker Computer Graphics (C version 2nd Ed.) Pearson education
- Foley, Vandam, Feiner, Hughes Computer Graphics principles (2nd Ed.) Pearson Education.

- W. M. Newman, R. F. Sproull Principles of Interactive computer Graphics TMH.
- D. F. Rogers, J. A. Adams Mathematical Elements for Computer Graphics (2nd Ed.) TMH
- F. S. Hill, Stephen Kelly, Computer Graphics using OpenGL, PHI Learning
- Z. Xiang, R. Plastock Schaums outlines Computer Graphics (2nd Ed.) TMH

MI-EC 04: Artificial Intelligence

(1) Introduction to Artificial Intelligence What is AI? Early work in AI, AI and related fields AI problems and Techniques

(2) Problems, Problem Spaces and Search : Defining AI problems as a State Space Search: example Production Systems Search and Control Strategies Problem Characteristics Issues in Design of Search Programs Additional Problems

(3) Heuristic Search Techniques Generate-and-test, Hill Climbing, Best First Search, Problem Reduction, Constraint Satisfaction, Mean-Ends Analysis

(4) Knowledge Representation Representations and Mappings, Approaches to Knowledge Representation, Knowledge representation method, Propositional Logic, Predicate logic, Representing Simple facts in Logic, Representing Instances and Isa relationships, Computable Functions and Predicates, Resolution, Forward and backward chaining

(5) Slot and Filler Structures : Weak Structures, Semantic Networks, Frames, Strong Structures, Conceptual Dependencies, Scripts

(6) Game Playing : Minimax Search Procedures, Adding alpha-beta cutoffs

(7) Planning: An example Domain: The Blocks world, Component of a planning system, Goal stack planning, Nonlinear planning ,Hierarchical Planning

(8) Learning : What is learning, Rote Learning, Learning by taking advice, Learning in problem solving, Learning from examples, Explanation based learning

Important Note: Teacher is supposed to take the practical implementation of the some of concepts in AI using Prolog language. Some marks are to be reserved in Continuous Evaluation/Assessment for the laboratory assignments/work.

References Books:

- Artificial Intelligence, Tata McGraw Hill, 2nd Edition, by Elaine Rich and Kevin Knight
- Artificial Intelligence: A Modern Approach by Stuart Russell, Peter Norvig, Prentice Hall, ISBN 0-13- 103805-2

- Introduction to Artificial Intelligence and Expert System, Prentice Hall of India Pvt. Ltd., New Delhi, 1997,2nd Printing, by Dan Patterson.
- Introduction to TURBO PROLOG, BPB Publication, by Carl Townsend

MI-EC 05: Image Processing

(1) **Evolutionary Computing:** Introduction, Possible Applications, Pros. And Cons. Principles of Evolutionary Computation, Historical Perspectives. , Genetic Algorithms, Evolutionary Strategies, Evolutionary Programming, Introduction to Representations, Binary Strings, Real-Valued Vectors, Various Selection Strategies, Introduction to Search Operators, Crossover and Mutation, Ant Colony Optimization, Combinatorial Function Optimization Problems, Exploration and Exploitation Fundamentals, Applications, Introduction to Particle Swarm Optimisation Monte- Carlo Methods and Simulated Annealing, Different Annealing Strategies, Introduction to Tabu Search, Introduction to Multi-objective Optimisation, Constraint Optimisation, Various Strategies, Introduction to Biogeography - based Optimisation, Case Studies

(2) **Digital Image Processing:** Introduction: Definition and origins of digital image processing (DIP), Example fields that use DIP, Fundamental steps and components in DIP Digital image fundamentals: Visual perception, Light and electromagnetic spectrum, Image sensing and acquisition, Image sampling and quantization, Basic relationships between pixels. Image enhancement in the spatial domain: Gray-level transformations, Image Histograms, Enhancement using arithmetic/logic operations, Smoothing and Sharpening, Spatial filters (Laplacian/Gradient. Image enhancement in the frequency domain: Discrete Fourier transform (DFT) and frequency domain, Smoothing and Sharpening with frequency-domain filters (Ideal, Butterworth, and Gaussian), Laplacian filters, The Convolution and Correlation theorems. Morphological image processing: Dilation and Erosion, Opening and Closing, Hit-or-miss transform, Basic morphological algorithms, Boundary extraction, Region filling. Image segmentation: Detection of discontinuities - Point, line, and edge, Region-based segmentation, Region growing, Region splitting and merging. Representation and description: Shape Representation, Chain codes, Polygonal approximations, Signatures, Boundary segments,, Skeletons, and descriptors, Shape numbers, Fourier descriptors, Statistical moments, Regional and Topological descriptors, Texture, and Moments

References Books:

- Gonzalez, R. C. and Woods, R. E. [2002/2008],Digital Image Processing, 2nd/3rd ed., Prentice Hall
- Sonka, M., Hlavac, V., and Boyle, R. [1999], Image Processing, Analysis and Machine Vision (2nd edition), PWS Publishing, or (3rd edition) Thompson Engineering, 2007
- Gonzalez, R. C., Woods, R. E., and Eddins, S. L. [2009], Digital Image Processing Using MATLAB, 2nd ed., Gatesmark Publishing, Knoxville, TN
- Anil K. Jain [2001],Fundamentals of digital image processing (2nd Edition), Prentice-Hall, NJ
- Multi-Objective Optimization Using Evolutionary Algorithms, Kalyanmoy Deb, John Wiley & Sons
- Multi-Objective Optimization Using Evolutionary Algorithms [Hardcover], Kalyanmoy Deb , Deb Kalyanmoy
- Essentials of Metaheuristics,Second Edition Sean Luke
- Genetic Algorithms, David E. Goldberg, Pearson Education India.
- Genetic Algorithms: The Design of Innovation , David E. Goldberg, Kumara Sastry, Springer-Verlag New York Incorporated
- Introduction to Evolutionary Algorithms, Xinjie Yu, Mitsuo Gen, Springer Science & Business Media

MI-EC 06: Programming with JAVA

(1) **Introduction to Java Programming:** Overview, Java Tools, Java Byte Code

(2) **Elementary Programming Concepts :** Variables and Identifiers, Java keywords, Data Types, Operators, Expression, Constants, Statements, Arrays

(3) **Classes and Packages :** Defining classes, Static Members, Using packages, Access Specifiers, Constructors, Finalisers referencing objects

(4) **Inheritance, nested and inner class :** Extending classes, Abstract Class Interface, Super Keyword, Final classes, Constructors and Inheritance, Dynamic Binding, Overriding methods

(5) **Exception and Input and Output :** Byte streams, Character streams, File i/o basics, Introduction to exception, Try and catch block and finally block, Inbuilt Exception.

(6) **String Handling and Exploring Java.lang :** String Operations, Character Extractions, Data Conversions, Modifying strings.

(7) Applet and Event Handling and Controls

(8) **Input and Output package :** Object serialization, reader and writer

(9) **Swings :** Layout Manager Layout Manager swing Controls Components Organizers, Jlish, Jtree, Jtables, Dialogue, File chooser, color chooser.

(10) **JDBC :** The design of JDBC, JDBC programming concepts making the connection, statement and result set class, Executing SQL commands, Executing Queries.

(11) **Multithreading :** Running multiple threads, The runnable interface Threads priorities Daemon, Thread States, thread groups Synchronization and Interthread Communication Deadlocks.

References Books:

- Herbert Schildt, A Complete Reference Java 2.

MI-EC 07: Programming with DOT NET

MS.NET Framework Introduction, VS.NET Introduction, C# Language, Collections and Generics, Assemblies and GAC, Exception Handling, IO Streams, Unsafe Code, Reflection and Attributes, Developing GUI Application Using WINFORMS, Database Programming Using ADO.NET, Managing Data using DataSet, N-Tier Layered Architecture Application, Delegates & Events, User Control and Custom Control Multithreading, Packaging and Deployment, Debugging and Diagnostics, Introduction to ASP, ASP.NET Introduction & Sample Programs, Validation Controls, Applying Themes and Styles to Controls, ASP.NET Architecture, Page Navigation Options, Creating a Layout Using Master Pages, User Control, ASP.NET State Management, Databound Controls, Creating Virtual Directory & Web Application, Global.asax & HttpApplication, Understanding Configuration File - Web.Config, Web Caching, Authentication & Authorization, Globalization and Localization.

References Books:

- Kogent, .NET 4.5 Programming 6-in-1, Learning Solutions Inc., (Wiley India Pvt. Limited), 2011.

MI-EC 08: Cloud Computing

(1) **Basics of Web Services:** Extensible Mark-up Language XML Introduction, some key aspects of XML, Document-centric XML Data-centric XML, XML-based Web Services,

Simple Object Access Protocol (SOAP), Web Service Definition Language (WSDL), UDDI (Universal Description Discovery and Integration) discovery that form a basis for Web Services, exploring JAXR, jUDDI, UDDI4J etc. Technologies include HTML, HTTP, XML, SOAP, and WSDL, Development of Java Web Services.

(2) **Virtualization and Resource Provisioning :** Introduction to Cloud Technologies, Study of Hypervisors Virtualization Technology: Virtual machine technology, virtualization applications in enterprises, Pitfalls of virtualization Multitenant software: Multi-entity support, Multi-schema approach, Multi-tenancy using cloud data stores, Data access control for enterprise applications

(3) **Introduction to Cloud Computing :** Definition, Characteristics, Components, Cloud provider, SAAS, PAAS, IAAS and Others, Organizational scenarios of clouds, Administering & Monitoring cloud services, benefits and limitations, Deploy application over cloud, Comparison among SAAS, PAAS, IAAS Cloud computing platforms: Infrastructure as service: Amazon EC2,Platform as Service: Google App Engine, Microsoft Azure, Utility Computing, Elastic Computing

(4) **Security in Clouds :** Cloud security fundamentals, Vulnerability assessment tool for cloud, Privacy and Security in cloud computing security architecture: Architectural Considerations-General Issues, Trusted Cloud computing, Secure Execution Environments and Communications, Micro-architectures; Identity Management and Access control-Identity management, Access control, Autonomic Security Cloud computing security challenges: Virtualization security management- virtual threats, VM Security Recommendations, VM-Specific Security techniques, Secure Execution Environments and Communications in the cloud.

Important Note: The teacher may take some practical demonstration of creating cloud if necessary infrastructure is made available in the laboratory (Amazon Cloud/Azure Cloud/ Google Cloud Platform)

References Books:

- Beginning Java web services, Henry Bequet et. al.,
- Programming web services with SOAP, James Snell et. al., O Reilly publisher

- Mastering Cloud Computing: Foundations and Applications Programming, Rajkumar Buyya, Christian Vecchiola, and Thamarai Selvi , Morgan Kaufmann Publication ISBN-10: 9780124114548 ISBN-13: 978-0124114548
- Distributed and Cloud Computing: From Parallel Processing to the Internet of Things Kai Hwang , Jack Dongarra, Geoffrey C. Fox, Elsevier; First edition ISBN-10: 9789381269237 ISBN-13: 978-9381269237

MI-EC 09: Object Oriented Modeling and Design

(1) **MODELING AS A DESIGN TECHNIQUE :** Modeling, The Object Modeling Technique.

(2) **OBJECT MODELING :** Objects and Classes, Links and Associations,Advanced Link and Association Concepts,Generalization and Inheritance, Grouping Constructs,A Sample Object Model.

(3) **ADVANCED OBJECT MODELING :** Aggregation, Abstract Classes, Generalization as Extension and Restriction, Multiple Inheritance, Metadata, Candidate Keys, Constraints.

(4) **DYNAMIC MODELING :** Events and States, Operations, Nested State Diagrams, Concurrency, Advanced Dynamic Modeling Concepts, A Sample Dynamic Model, Relation of Object and Dynamic Models.

(5) **FUNCTIONAL MODELING :** Functional Models, Data Flow Diagrams, Specifying Operations, Constraints, A Sample Functional Model, Relation of Functional to Object and Dynamic Models.

(6) **METHODOLOGY PREVIEW :** OMT as a Software Engineering Methodology, The OMT Methodology, Impact of an Object-Oriented Approach.

(7) **ANALYSIS :** Overview of Analysis, Problem Statement, Automated Teller Machine Example, Object Modeling, Dynamic Modeling, Functional Modeling, Adding Operations, Iterating the Analysis.

References Books:

- Object Oriented Modeling and Design By James Rumbaugh, Michael Blaha
- The Unified Modeling Language User Guide By Grady Booch, James Rumbaugh.
- The Unified Modeling Language Reference Manual By James Rumbaugh, Ivar Jacobson
- Object-Oriented software Engineering By Timothy, Robert Lagantere.

MI-EC 10: Programming using Mobile Technology

(1) **Introduction :** What is Android, Android versions and its feature set The various Android devices on the market, The Android Market application store, Android Development Environment - System Requirements, Android SDK, Installing Java, and ADT bundle - Eclipse Integrated Development Environment (IDE), Creating Android Virtual Devices (AVDs)

(2) **Android Architecture Overview and Creating an Example Android Application:** The Android Software Stack, The Linux Kernel, Android Runtime - Dalvik Virtual Machine, Android Runtime Core Libraries, Dalvik VM Specific Libraries, Java Interoperability Libraries, Android Libraries, Application Framework, Creating a New Android Project ,Defining the Project Name and SDK Settings, Project Configuration Settings, Configuring the Launcher Icon, Creating an Activity, Running the Application in the AVD, Stopping a Running Application, Modifying the Example Application, Reviewing the Layout and Resource Files,

(3) **Android Software Development Platform:** Understanding Java SE and the Dalvik Virtual Machine , The Directory Structure of an Android Project , Common Default Resources Folders , The Values Folder , Leveraging Android XML, Screen Sizes , Launching Your Application: The AndroidManifest.xml File , Creating Your First Android Application

(4) **Android Framework Overview:** Android Application Components, Android Activities: Defining the UI, Android Services: Processing in the Background, Broadcast Receivers: Announcements and Notifications Content Providers: Data Management, Android Intent Objects: Messaging for Components Android Manifest XML: Declaring Your Components

(5) **Understanding Android Views, View Groups and Layouts:** Designing for Different Android Devices, Views and View Groups, Android Layout Managers, The View Hierarchy, Designing an Android User Interface using the Graphical Layout Tool

(6) **Graphical User Interface Screen with views:** Displaying Text with TextView, Retrieving Data from Users, Using Buttons, Check Boxes and Radio Groups, Getting Dates and Times from Users, Using Indicators to Display Data to Users, Adjusting Progress with SeekBar, Working with Menus using views

(7) **Displaying Pictures:** Gallery, ImageSwitcher, GridView, and ImageView views to display images, Creating Animation

(8) **Files, Content Providers, and Databases:** Saving and Loading Files, SQLite Databases, Android Database Design, Exposing Access to a Data Source through a Content Provider, Content Provider Registration, Native Content Providers

(9) **Intents and Intent Filters:** Intent Overview, Implicit Intents, Creating the Implicit Intent Example Project, Explicit Intents, Creating the Explicit Intent Example Application, Intents with Activities, Intents with Broadcast Receivers

(10) **A Basic Overview of Android Threads and Thread handlers:** An Overview of Threads, The Application Main Thread, Thread Handlers, A Basic Threading Example, Creating a New Thread, Implementing a Thread Handler, Passing a Message to the Handler

(11) **Messaging and Location-Based Services:** Sending SMS Messages Programmatically, Getting Feedback after Sending the Message Sending SMS Messages Using Intent Receiving, sending email, Introduction to location-based service, configuring the Android Emulator for Location-Based Services, Geocoding and Map-Based Activities

(12) **Multimedia:** Audio, Video, Camera Playing Audio and Video, Recording Audio and Video, Using the Camera to Take and Process Pictures

(13) **Windows Phone App Development Fundamentals:** Introduction to Windows Phone App Development, Installing the Windows Phone SDK, Creating Your First XAML for Windows Phone App

(14) **Fundamental Concepts in Windows Phone Development:** Understanding the Role of XAP Files, the Windows Phone Capabilities Model, the Threading Model for XAML-Based Graphics and Animation in Windows Phone, Understanding the Frame Rate Counter, The Windows Phone Application Analysis Tool, Reading Device Information, Applying the Model-View-ViewModel Pattern to a Windows Phone App, Property Change Notification, Using Commands

References Books:

- Bill Phillips, Chris Stewart, Brian Hardy, and Kristin Marsicano, Android Programming:
- The Big Nerd Ranch Guide, Big Nerd Ranch LLC, 3rd edition, 2017;
- Rajiv Ramnath, Roger Craws, and Paolo Sivilotti, Android SDK 3 for Dummies, Wiley.
- B. Phillips et al., Android Programming: Big Nerd Ranch Guide;
- Christian Keur and Aaron Hillegass, iOS Programming: The Big Nerd Ranch Guide, 6th edition, 2016;
- Valentino Lee, Heather Schneider, and Robbie Schell, Mobile Applications: Architecture,

- Design and Development, Prentice Hall, 2004;
- Tomasz Nurkiewicz and Ben Christensen, Reactive Programming with RxJava, OReilly Media, 2016;
- Raoul-Gabriel Urma, Mario Fusco, and Alan Mycroft, Java 8 in Action: Lambdas, Streams, and Functional-Style Programming, Manning Publications, 2015;

MI-EC 11: Compiler Construction

(1) **Introduction to Compilers:** Overview of Compilation, Analysis of source program, phases of compiler, compiler construction tools namely Lex,Yacc etc.

(2) **Lexical Analysis:** Specification and recognizing of tokens, Regular Expressions, Finite Automata (NFA, DFA), Algorithms for conversion from regular expression to NFA and from NFA to DFA. Implementation of Lexical Analyzer from DFA

(3) **Syntax Analysis:** Context-free grammars, ambiguity specifying operator precedence, Overview of Parsing, Types of parsing including Top-down parsing, Bottom-up parsing, Operator-precedence parsing, LR parsers etc.

(4) **Symbol Table Construction and Issues:** Organization, operations issues such as scope and overloading and their effect on symbol table design, implementation, and operations

(5) **Syntax Directed Translation** Syntax-directed definitions, translation schemes, synthesized and inherited attributes, propagation of attribute values through syntax tree

(6) **Construction of Abstract Syntax Tree:** Binary tree representation of expressions and statements, construction of binary tree representation using a stack

(7) **Semantic Analysis:** Rules that cannot be described using a context-free grammar, Type checking rules for expressions and statements and issues such as type equivalence, overloading of functions and operators

(8) **Intermediate Code Generation:** Three-address code for expressions and statements including assignments, conditionals, loops, procedure calls and generation of temporary variables and tables

(9) **Code Optimization:** Principal sources of optimization, Introduction to data flow analysis and equations, code improving transformations.

References Books:

- Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman, Compilers: Principles, Techniques, & Tools, (Second Edition,Addison-Wesley).

- David Galles, Modern Compiler Design, (First Edition,Addison-Wesley), 2005.
- Thomas Pittman and James Peters, Art of Compiler Design, The: Theory and Practice, (First Edition, Prentice Hall), 1992.
- Cooper and Torczon, Engineering a Compiler, (First Edition, Elsevier), 2004.

MI-EC 12: Programming with Advanced JAVA

(1) **JAVA Basic Reviews:** Java streaming - Networking - Event handling - Multithreading - Byte code Interpretation - Customizing application - Data Structures - Collection classes.

(2) **Distributed Computing:** Custom sockets - Remote Method Invocation - Activation - Object serialization -Distributed garbage collection - RMI - IIOP - Interface definition language - CORBA - JINI overview.

(3) **JAVA Beans And Swing:** Bean concepts - Events in bean box - Bean customization - Persistence - Application - deployment using swing - Advanced swing techniques - JAR file handling.

(4) **JAVA Enterprise Applications:** JNI - Servlets - Java Server Pages - JDBC - Session beans - Entity beans - Programming and deploying enterprise Java Beans - Java transactions.

(5) **Related JAVA Techniques:** Java Media Frame work - 3D graphics - Internationalization - Case study - Deploying n-tier application, E- commerce applications.

References Books:

- Deitel and Deitel , Java How to program, Prentice Hall , 4 th Edition, 2000.
- Gary Cornell and Cay S. Horstmann, Core Java Vol 1 and Vol 2 , Sun Microsystems Press, 1999.
- Stephen Asbury, Scott R. Weiner, Wiley, Developing Java Enterprise Applications, 1998

MI-EC 13: Quantum Computing

(1) **Fundamentals:** Quantum bits, quantum computation, single and multiple qubit gates, quantum circuits, quantum algorithms, classical computations on a quantum computer, quantum information theory

(2) **Quantum Computation :** Linear operators and matrices, Pauli matrices, adjoints and hermitian operators, the polar and singular value decompositions, state space, quantum

measurement, controlled operations, universal quantum gates, the quantum Fourier transform, phase estimation, applications to order-finding and factoring, the quantum search algorithm.

References Books:

- Michael Nielsen, Quantum Computation and Quantum Information (Cambridge University Press)
- Ronald De Wolf , Lecture notes on Quantum Computing (https://homepages.cwi.nl/ rdewolf/qcnotes.pdf)

MI-EC 14: Advanced Databases and NoSQL

(1) Introduction to Procedural Language Support to SQL: Writing Functions/Triggers using PostgreSQL/MySQL

(2) An Overview of NoSQL: Review of the Relational Model, ACID Properties, Distributed Databases: Sharding and Replication, Consistency, The CAP Theorem, NoSQL Data Models

(3) Introduction to Hadoop and HDFS: Overview of Hadoop and DFS, HDFS Deployment, Core HDFS Services, Check Pointing, Federated and High Availability HDFS, Multi-node Cluster with Docker

(4) Introduction to MongoDB: The Document Data Model, Documents and Collections, MongoDB Use Cases, Embedded Data Models, Normalized Data, Replication via Replica Sets, MongoDB Design, MongoDB and the CAP Theorem, The MongoDB Data Manipulation Language, Transactions, Atomicity, and Documents, Durability and Journaling, Batch Processing and Aggregation, Indexing, Auto-Sharding, Shard Keys, and Horizontal Scalability, Writing to Shards, MongoDB as a File System

(5) Introduction to Column Store Databases (Cassandra): The Column-Family Data Model, Databases and Tables, Columns, Types, and Keys, The Data Manipulation Language, Architecture, Key Spaces, Replication, and Column-Families, The CAP Theorem, Consistent Hashing, Managing Cluster Nodes

(6) Introduction to Neo4j : Overview of Graph Theory, The Graph Data Model, Relationships as First-Class Citizens, Graph Database Use Cases, Neo4j Design: Standalone and Cluster,

ACID Properties and the CAP Theorem, Transaction Management with JTA, CRUD Operations with the Neo4j Core API, Navigating Graphs with the Traversal API, The Neo4j REST API, The Cypher Data Manipulation Language, Querying as Graph Traversal

Note: Teacher/Students are expected to visit the websites for the above NoSQL databases and read the documentation instead of relying on books

Reference Books

- Beginning Neo4j by Chris Kemper, Apress
- Learning Neo4j 3.x - Jerome Baton, Packt Publishing Limited
- Practical MongoDB by Shakuntala Gupta Edward, Apress
- The Definitive Guide to MongoDB, by David Hows , Eelco Plugge, Peter Membrey , Apress
- Hadoop: The Definitive Guide by Tom White, Shroff Publishers & Distributers Private Limited
- Hadoop from the Beginning: The Basics by Nicholas Brown Createspace Independent Pub

MI-EC 15: Web Technologies

(1) Foundation: The Node.js framework, Installing Node.js, Using Node.js to execute scripts

(2) HTTP and HTTPs: Making a simple server, when to use HTTP and HTTPs, Server ports and listening, HTTP requests and responses, Request and response headers and body, Creating a response to incoming requests, Building a simple HTTP server with static files

(3) File System & Modules: Synchronous vs. asynchronous I/O, Path and directory operations, –dirname and –filename, Asynchronous file reads and writes, Defining modules with exports, Modules are singletons, Creating a package, Module scope and construction

(4) Buffers, Streams, and Events: Using buffers for binary data, flowing vs. non-flowing streams, Streaming I/O from files and other sources, processing streams asynchronously, Configuring event handlers

(5) Express: The model-view-controller pattern, Building a front-end controller, Defining routes, Creating actions, Using REST, Reading POST data, Building Handlebars helpers, Adding middleware

(6) Data Sources: How Node.js connects to databases, RDBMS databases and NoSQL databases, Connecting to RDBMS and NoSQL databases, Performing CRUD operations, Building client requests to web services,

(7) Angular Components: Component Life Cycle, Services, Single Page Applications, Directives, Forms, Pipes, Communication Between Component

Reference Book/ URL :

- Any recent updated books for Angular JS and node.JS
- https://docs.angularjs.org/
- https://nodejs.org/en/docs/

Module (B): Mathematics Courses

MT-EM 01: Operation Research

(1) **Modeling with Linear Programming :** Two variable LP model, graphical LP solutions, selected LP applications.

(2) **Simplex method and Sensitivity Analysis :** LP model in equation form, transition from graphical to algebraic solution, simplex method, artificial starting solution, special cases in the simplex method, sensitivity analysis.

(3) **Duality and Post-Optimal Analysis :** Definition of the dual problem, primal-dual relationships, economic interpretation of duality, additional simplex algorithms.

(4) **Transportation Model and its Variants :** Definition of the transportation model, non traditional transportation models, transportation algorithm, assignment model.

(5) **Network Model :** Scope and definition of network models, minimal spanning tree algorithm, shortest root problem, maximal flow model, CPM and PERT.

(6) **Advanced Linear Programming :** Simplex method fundamentals, revised simplex method, bounded variable algorithm, duality.

(7) **Integer Linear programming :** Illustrative applications, integer programming algorithms.

NB : Use suitable mathematical software to solve relevant problems.

Reference Book(s):

- Hamy A.Taha, Operations Research, (Eightth Edition, Prentice Hall of India), 2008.
- J. K. Sharma, Operations Research, (Third Edition, Macmillan India Ltd.), 2008.
- P. K. Gupta and D. S. Haria, Operations Research, (Fifth Edition, S. Chand), 2014.

MI-EM 02: Computational Geometry

(1) Transformations of the Plane: Translations, reflections, rotations, shears, concatenation of transformations, applications

(2) Homogenous coordinates: Homogenous coordinates, points at infinity, projective plane, transformations in homogenous coordinates

(3) Transformations of the Space: Translations, scalings, reflections, rotations about coordinate axes, rotation about an arbitrary line, reflection in an arbitrary plane, applications to Computer-aided Design, projections

(4) Curves : Curve rendering, parametric Curves, arclength and reparametrization, Classification of Conics, Intersections of a Conic with a Line, parametrization of an irreducible conic, Conics in space, applications of conics

(5) Bezier Curves: Bezier curves of low degree, linear Bezier curves, quadratic Bezier curves, cubic Bezier curves, the general Bezier curve, properties of the Bernstein polynomials, properties of Bezier curves, applications

(6) B-splines : Introduction to B-splines, properties of the B-spline Curve

Reference Books:

- Duncan Marsh, Applied Geometry for Computer Graphics and CAD (Springer, Second Edition)
- de Berg, van Kreveld, Overmars, and Schwarzkopf, Computational Geometry Algorithms and Applications, 2nd Edition, (Springer-Verlag, 2000).

MT-EM 03 : Cryptography

(1) **Introduction to cryptography:** Cryptography in Modern world. Substitution cipher, Ceaser cipher as a special case of substitution cipher, Monoalphabetic ciphers, Transposition Cipher, Polyalphabetic substitution ciphers, Vigenere Cipher, Introduction to polygraphic substitution ciphers, cryptanalysis of substitution cipher

(2) **Symmetric key cryptography:** Introduction and overview, Stream Cipher, one-time Pad, Block cipher, Modes of operation Electronic code book, cipher block chaining, Cipher feedback, Algorithms: Data Encryption Standard, Advanced Encryption Standard, IDEA (International Data Encryption Algorithm), Attacks against DES, AES, IDEA

(3) **Public key Cryptography:** Introduction and Overview, The RSA algorithm, Generation of keys, Exchange messages, Diffie Hellman Key Agreement protocol, EIGamal Encryption, Algorithms: Discrete Logarithm, MD5, Attacks against RSA, Discrete Logarithm.

(4) **Hashing:** Motivation and applications, cryptographically secure hashing, message authentication codes (MAC), HMAC, Network security, Secure Socket layer (SSL), Definition of secrete sharing, visual secret schemes, Shamirs sharing scheme. Applications of Cryptography: - Digital Signature, Kerberos, Pretty Good privacy Internet protocol security Note

(5) **Hands on (Optional) :** Applications of cryptography such as: Digital Signature, Kerberos, Pretty Good privacy, Internet protocol security. All the topics based on Ciphers can be implemented using C, C++ or python as Programming Exercises or Assignments.

Reference Books:

- Neal Koblitz, A Course in Number Theory and Cryptography (Springer, Second Edition)
- Robert Edward Lewand: Cryptological Mathematics (Mathematical Association of America).
- D. R. Stinson: CRYPTOGRAPHY, Theory and practice, CRC Press, 1995
- Jeffrey Hoffstein, Jill Pipher, Joseph H. Silverman: An introduction to Mathematical Cryptography, Springer
- Adam J. Elbirt: (CRC press): Understanding and Applying cryptography and Data security.
- Bruice Schneier: Applied Cryptography (Wiley India Edition)
- Atul Kahate: Cryptography and Network security (Tata McGraw Hill)

MT-EM 04: Statistical Inference

(1) **Correlation and Regression Analysis:** Introduction and Scatter Diagrams, Karl Pearsons Coefficient of Correlation, Properties and Problems, Spearmens Rank correlation coefficient. method of Concurrent Deviations, interpretation of r and Probable Error, Linear Regression, Lines of Regression, Theorems on Regression Coefficients, Yules Rule, Order of Regression coefficients, Statistical Inferences about the Regression Parameters, Variance of the Residual and the standard error of the estimate, Introduction to Multiple Correlation, Multiple linear Regression.

(2) **Chi square distribution:** Introduction of Chi-square Distribution, Chi-square test for Goodness of Fit and its conditions for validity, Chi-Square test for independence of attributes, Degrees of Freedom, test for equality of several Proportions, Chi-square test for population variance, applications of Chi-square Distribution

(3) **Small Sample Tests:** Critical Values and Applications of t distribution, Confidence Interval for difference of two means, Paired t-test for difference of two Means, t-test for significance of an observed sample correlation coefficient, Fishers Z Transform, F distributions and its applications, F-test for equality of population variances, relation between t, F and Chi-square Distributions.

(4) **Likelihood Ratio Tests:** Notion of Likelihood Ratio Test (LRT), construction of LRT for mean of normal distribution (one and two sided when variance is known/unknown), construction of LRT for variance of normal distribution (one and two sided when mean is known/unknown), LRT for parameters of Binomial distribution (two sided) , LRT as a function sufficient statistics, statement of Asymptotic Distribution of -2 log lambda(x).

(5) **Non Parametric Tests:** Introduction to Non Parametric tests, Advantages and Limitations, Distribution Free Statistics, Sign Test, Wilcoxon Signed Rank Test, Mann Whitney Test,

(6) **Analysis of Variance (ANNOVA):** One-Way analysis of Variance, Two-Way analysis of variance, The Kruskal-Wallis One -Way analysis of variance by ranks, The Friedman Two-Way analysis of variance by ranks.

References Books:

- Introduction to Probability and Statistics for Engineers and Scientists, by Sheldon M. Ross (Fourth Edition).
- Biostatistics, A Foundation for Analysis in Health Sciences, by Wayne W. Daniel (Eighth Edition, Wiley Publications)
- Mathematical Statistics, by Parimal Mukhopadhyay.
- Statistics for the Life Sciences, by M. Samules, J. Witmer and A. Schaffner (Fifth Edition, Pearson India)
- Probability and Statistics for Engineers, by Richard Gupta, C B Gupta.

MI-EM 05: Integral Transforms

- **Laplace Transform :** Properties of Laplace Transform, Laplace Transform of the derivatives of function, Inverse Laplace transform, Properties of inverse Laplace transform, Inverse Laplace transform of derivatives, Convolution theorem, Heavisides expansion theorem. Application of Laplace Transform, Solution of ODEs and PDEs.
- **Fourier Transforms :** Fourier integral theorem, Fourier transform Pairs, Properties of Fourier transform, Fourier cosine transform, Inverse Fourier Transform, Inverse Fourier sine Transform, Inverse Fourier cosine Transform, Properties of Fourier Transforms, Modulation theorem, Convolution theorem, Fourier Transform of the derivatives of functions, Parsevals identity, Application of Fourier Transforms to the solution of initial & boundary value problems.

- **Finite Furier Transform :** Finite Fourier sine and cosine transforms, inversion formula for sine and cosine transform,multiple finite furier transforms, operational properties of finite Fourier sine and cosine transforms, convolution theorem, applications.
- **Wavelet Transform :** Continuous Wavelet Transform, Time-Frequency Space Analysis, Short-Time Fourier Transform, Wigner Distribution and Ambiguity Functions, Properties of the Wavelets, Admissible Condition, Regularity, Multiresolution Wavelet Analysis, Linear Transform Property, Examples of the Wavelets, Discrete Wavelet Transforms, Time-Scale Space Lattices, Wavelet Frame.

References Books:

- Larry C. Andrews and Bhimsen K. Shivamoggi, Integral Transforms for Engineers, Prentice Hall, 2003.
- A. N. Srivastava and Mohammad Ahmad, Integral Transforms and Fourier Series, Narosa Publishing House, 2015.

MT-EM 06: Financial Mathematics

(1) Introduction to options and markets: types of options, interest rates and present values.

(2) Black Sholes model : arbitrage, option values, pay offs and strategies, put call parity, Black Scholes equation, similarity solution and exact formulae for European options, American option, call and put options, free boundary problem.

(3) Binomial methods : option valuation, dividend paying stock, general formulation and implementation.

(4) Monte Carlo simulation : valuation by simulation

(5) Finite difference methods : explicit and implicit methods with stability and conversions analysis methods for American options- constrained matrix problem, projected SOR, time stepping algorithms with convergence and numerical examples.

(6) Lab component: implementation of the option pricing algorithms and evaluations for Indian companies.

Reference Books:

- D.G.Luenberger, Investment Science, Oxford University Press,1998.
- J.C.Hull , Options, Futures and Other Derivatives, 4th ed., Prentice- Hall ,New York,2000.
- J.C.Cox and M.Rubinstein, Option Market, Englewood Cliffs,N.J.: Prentice- Hall,1985.

- C.P. Jones. Investments, Analysis and Measurement, 5th ed.,John Wiley and Sons,1996.

MI-EM 07: Applied Linear Algebra

(1) **Basics :** Projections and orthogonalization, Least squares method, the Fast Fourier transform, applications of determinants, diagonalization and powers of matrices, differential equations and matrix exponential

(2) **Positive Definite Matrices :** Minima, maxima and saddle points, tests for positive definiteness, semidefinite and indefinite matrices, Minimum principles and Rayleigh Quotient, Finite element method

(3) **Computations with Matrices :** Norm and condition number of a matrix, computation of eigenvalues, iterative methods for Ax=b

(4) **Decomposition methods :** Singular Value Decomposition(SVD), Applications, Pseudoinverse using SVD

References Books:

- Gilbert Strang, Linear Algebra and its Applications, (Brooks/Cole, Third Edition)
- Peter Lax, Linear Algebra (John Wiley & Sons Inc)
- Gilbert Strang, Introduction to Applied Mathematics (Wellesley Cambridge Press)

MI-EM 08 : Differential Geometry

Graphs and level sets, vector fields, tangent spaces, surfaces, vector fields on surfaces, orientation, gauss map, geodesics, parallel transport,Weingarten map, curvature, arc length and line integrals, curvature of surfaces, parametrized surfaces, surface area and volume, exponential map, surfaces with boundary.

Reference Books:

- John A. Thorpe, Elementary topics in differential Geometry, Springer, (2004)
- B Oneill : Elementary differential Geometry, (Academic - New York)

MI-EM 09: Rings and Fields

(1) **Rings :** Definition and examples, ideals, ring homomorphisms, fundamental theorem of ring homomorphisms, integral domains, fields, polynomial ring, Euclidean domains and division algorithm for polynomials, unique factorization in the ring of integers and polynomial ring K[x], criterion for irreducible polynomials, Eisenstein criterion

(2) **Fields :** Examples of finite and infinite fields, field extensions, degree of extension, construction of finite fields, primitive elements, cyclotomic polynomials, irreducible polynomials over finite fields, Factorization of polynomials over finite fields, Chinese Remainder theorem for polynomials, Berlekamps algorithm. Application: Any one application to either Coding theory or RSA cryptosystem.

References Books:

- Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra (Springer, Second Edition)
- G. Mullen and C. Mummert, Finite Fields and Applications (AMS, Indian Edition)
- John M. Howie, Fields and Galois Theory, (Springer)

MT-EM 10: Coding Theory

(1) **Error detection:** correction and decoding: Communication channels, Maximum likelihood decoding, Hamming distance, Nearest neighbor / minimum distance decoding, Distance of a code.

(2) **Linear codes:** Vector spaces over finite fields, Linear codes, Hamming weight, Bases of linear codes, Generator matrix and parity check matrix, Equivalence of linear codes, Encoding with a linear code, Decoding of linear codes, Cossets, Nearest neighbor decoding for linear codes, Syndrome decoding.

(3) **Cyclic codes:** Definitions, Generator polynomials, Generator and parity check matrices, Decoding of cyclic codes, Burst-error-correcting codes.

(4) **Some special cyclic codes:** BCH codes, Definitions, Parameters of BCH codes

Reference Books:

- San Ling and Chaoing xing, Coding Theory- A First Course
- Raymod Hill, A First Course in Coding Theory (Oxford)
- Lid and Pilz, Applied Abstract Algebra Second Edition

MI-EM 11 : Numerical Analysis

(1) Iterative solutions of nonlinear equation: bisection method. Fixed-point iteration, Newton's method, secant method, acceleration of convergence, Newton's method for two nonlinear equations, polynomial equation methods.

(2) Polynomial interpolation: interpolation polynomial, divided difference interpolation, Aitken's formula, finite difference formulas, Hermite's interpolation, double interpolation.

(3) Linear systems of Equations: Gauss Elimination, Gauss-Jordan method, LU decomposition, iterative methods, and Gauss- Seidel iteration.

(4) Numerical Calculus: Numerical differentiation, Errors in numerical differentiation, Numerical Integration, Trapezoidal rule, Simpson's 1/3 - rule, Simpson's 3/8 rule, error estimates for Trapezoidal rule and Simpson's rule.

(5) Numerical Solution of Ordinary differential Equations : Solution by Taylor series, Picard Method of successive approximations, Euler's Method, Modified Euler Method, Runge-Kutta Methods, Predicator-Corrector Methods.

(6) Eigenvalue Problem: Power method, Jacobi method, Householder method.

NB : Students are also required to use suitable programming language to solve relevant problems.

Reference Book:

- M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical methods for scientific and engineering computations, (Sixth Edition, New Age International Publishers), 2015.
- S. S. Sastry, Introduction Methods of Numerical Analysis (4th Edition) (Prentice-Hall).
- K .E. Atkinson: An Introduction to Numerical Analysis.
- J. I. Buchaman and P. R. Turner, Numerical Methods and Analysis

MT-EM 12 : Partial Differential Equations

(1) **First and second order linear equations:** terminologies, superposition principle, linear dependence, First order linear equations, initial value problem, classification of second order equations, well posedness

(2) **Heat equation:** Derivation of heat equation, initial boundary value problems, homogeneous boundary conditions, non-homogeneous boundary conditions, Robin boundary conditions, Infinite domain problems, maximum principle, energy method, uniqueness of solutions.

(3) **Wave equation:** Derivation of wave equation, Initial value problems, wave reflection problems, Initial boundary value problems, Energy method

(4) **Laplace equation:** boundary value problems, separation of variables, Fundamental solution, Greens identity, Greens function, Properties of harmonic function, Well posedness issues

(5) First order quasilinear equations, scalar conservation law, Rankine-Hugoniot condition, weak solutions, entropy condition, traffic flow problem, First order nonlinear equations, systems of first order equations

(6) **Fourier series and Eigenvalue problems:** Fourier convergence theorems, Derivations of Fourier series, Sturm-Liouville Problems.

Reference Books:

- H. Hattori, Partial Differential Equations, Methods, Applications and Theories, World Scientific publications, 2014.
- T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa, 2003.
- J. Brown and R.V. Churchill, Fourier Series and Boundary Value Problems, (McGraw-Hill)

MT-EM 13 : Bezier Curves and Splines

(1) **Basics of of Bezier Curves :** Bezier curves of low degree , linear Bezier Curves, quadratic Bezier Curves, Cubic Bezier, the effect of adjusting a control point , general Bezier curve, convex hulls, properties of Bezier curves, subdivision of a Bezier curve, applications, rendering, intersection of two Bezier curves

(2) **Bezier Curves :** Spatial Bezier curves, derivatives of Bezier curves, conversions between representations, piecewise Bezier curves, rational Bezier curves, properties of rational Bezier curves, de Casteljau Algorithm for rational curves, projections of rational Bezier curves, derivatives of Rational Bezier Curves, B-splines, Integral B-spline curves, properties of the B-spline curve, B-spline types, application to font design

(3) **Surfaces :** Quadric surfaces, Bezier and B-spline surfaces, surface constructions, extruded surfaces, ruled surfaces, surface subdivision, geometric modelling and CAD

Reference Books:

- Duncan Marsh, Applied Geometry for Computer Graphics and CAD (Springer, Second Edition)