NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
DEPARTMENT OF MATHEMATICS

Proposal for 2-year **M. Tech Program** in '**Operations Research**' from the **Session 2015-2016**

Name of the Course :**M. Tech in Operations Research**

No. of Intake :**23**

Duration of Course :**4 Semesters i.e. 2 years**

Eligibility criteria :B.E/B. Tech in any branch of Engineering/Technology, M. Sc in Mathematics/ Statistic, MCA. At least 60% marks or 6.5 CGPA in the qualifying examination. 5% marks relaxation is applicable for SC/ST candidates.

Admission Procedure :Through CCMT/On the basis of written test and Viva Voce to be conducted by the department.

Tuition Fees : As per Institute rules

Curriculum : Attached.

Full Time Course

Semester-I

Subject Code	Subject Name	L	T	P	C
MA1001	Probability and Statistics	3	1	0	4
MA1002	Fundamentals of Operations Research	3	1	0	4
MA1003	Optimization Techniques	3	1	0	4
	Elective –I	3	1	0	4
	Elective –II	3	1	0	4
MA1051	Sessional - I (Programming Lab)	0	0	4	2
MA1052	Sessional - II (Operations Research Lab)	0	0	4	2

Total Credit - 24

Semester-II

Subject Code	Subject Name	L	T	P	C
MA2001	Advanced Operations Research	3	1	0	4
MA2002	Advanced Optimization Techniques	3	1	0	4
	Elective – III	3	1	0	4
	Elective – IV	3	1	0	4
	Elective – V	3	1	0	4
MA2051	Sessional- III (Computing Lab)	0	0	4	2
MA2052	Seminar- I (Non project)	0	0	2	1
MA2053	Project-I	0	0	2	1

Total Credit - 24

Semester-III

Subject Code	Subject Name	L	T	P	C
MA3051	Project – II	0	0	0	11
MA3052	Project Seminar – I	0	0	0	2

Total Credit - 13

Semester-IV

Subject Code	Subject Name	L	T	P	C
MA4051	Project – III	0	0	0	11
MA4052	Seminar II &Viva Voce	0	0	0	3

Total Credit – 14

Total Course Credit – 75

Part Time Course

Semester-I

Subject Code	Subject Name	L	T	P	C
MA1001	Probability and Statistics	3	1	0	4
MA1002	Fundamentals of Operations Research	3	1	0	4
MA1003	Optimization Techniques	3	1	0	4
MA1051	Sessional - I (Programming Lab)	0	0	4	2

Total Credit - 14

Semester-II

Subject Code	Subject Name	L	T	P	C
MA2001	Advanced Operations Research	3	1	0	4
MA2002	Advanced Optimization Techniques	3	1	0	4
	Elective – III	3	1	0	4
MA2051	Sessional- III (Computing Lab)	0	0	4	2

Total Credit - 14

Semester-III

Subject Code	Subject Name	L	T	P	C
	Elective –I	3	1	0	4
	Elective – II	3	1	0	4
MA1052	Sessional - II (OR Lab)	0	0	4	2

Total Credit - 10

Semester-IV

Subject Code	Subject Name	L	T	P	C
	Elective – IV	3	1	0	4
	Elective – V	3	1	0	4
MA2052	Seminar- I (Non project)	0	0	2	1
MA2053	Project-I	0	0	2	1

Total Credit - 10

Semester-III

Subject Code	Subject Name	L	T	P	C
MA3051	Project – II	0	0	0	11
MA3052	Project Seminar – I	0	0	0	2

Total Credit - 13

Semester-IV

Subject Code	Subject Name	L	T	P	C
MA4051	Project – III	0	0	0	11
MA4052	Seminar II & Viva Voce	0	0	0	3

Total Credit – 14

Total Course Credit – 75

List of Electives:

Sl. No.	Subject Code	Subject Name
1	MA9011	Programming Language and Data Structure
2	MA9012	Mathematical Modelling
3	MA9013	Graph Theory and its Applications
4	MA9014	Fuzzy Logic and Fuzzy Decision Making
5	MA9015	Automata & Algorithms
6	MA9016	Information and Coding Theory
7	MA9017	Soft Computing
8	MA9018	Financial Mathematics
9	MA9019	Discrete Mathematics
10	MA9020	Advanced Statistical Analysis
11	MA9021	Decision Theory
12	MA9022	Cryptography
13	MA9023	Numerical Methods
14	MA9024	Reliability Theory

SUMMARY OF COURSES

Sub Discipline: DEPARTMENTAL CORE

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 1001	Probability and Statistics	3-1-0	4	Dr S.Maitra& Dr K Basu
MA 1002	Fundamentals of Operations research	3-1-0	4	Dr S.S.Mondal& Dr A.Pal
MA-1003	Optimization Techniques	3-1-0	4	Dr K;Basu& Dr S.S.Mondal
MA-2001	Advanced Operations Research	3-1-0	4	Dr K.Basu
MA-2002	Advanced Optimization Techniques	3-1-0	4	Dr S.Kar& Dr S.S.Mondal

Sub Discipline: DEPARTMENTAL ELECTIVES

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9011	Programming Language and Data Structure	3-1-0	4	Dr G.Panigrahi
MA 9012	Mathematical Modelling			Dr S Maitra
MA 9013	Graph Theory and its Applications	3-1-0	4	Dr A.Pal
MA 9014	Fuzzy Logic and Fuzzy Decision Making			Dr S .Kar
MA 9015	Automata & Algorithms			Dr S. Kar & Dr G Panigrahi
MA 9016	Information and Coding Theory	3-1-0	4	Dr L. K. Dey&Dr. S. Bagchi
MA 9017	Soft Computing			Dr S.Kar
MA 9018	Financial Mathematics			Dr S Maitra
MA 9019	Discrete Mathematics			Dr S. Kar & Dr G Panigrahi
MA 9020	Advanced Statistical Analysis			Dr K.Basu
MA 9021	Decision Theory			Dr S S Mondal
MA 9022	Cryptography			Dr S.Bagchi

MA 9023	Numerical Methods			Dr S.S.Mondal
MA 9024	Reliability Theory			Dr K Basu

Sub Discipline: LABORATORY & SESSIONAL COURSES

SUBJECT CODE	SUBJECT	L-T-P	CREDIT
MA-1051	Sessional – I (Programming Lab)	0-0-4	2
MA-1052	Sessional – II (Programming Research Lab)	0-0-4	2
MA-2051	Sessional-III (Computing Lab)	0-0-4	2

Sub Discipline: PROJECT, SEMINAR etc.

SUBJECT CODE	SUBJECT	L-T-P	CREDIT
MA-2052	Seminar-I (Non Project)	0-0-2	1
MA-2053	Project –I	0-0-2	1
MA-3051	Project –II	0-0-0	11
MA-3052	Project Seminar–I	0-0-0	2
MA-4051	Project –III	0-0-0	11
MA-4052	Sessional-II (Viva Voce)	0-0-0	3

Semester –I

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 1001	**Probability and Statistics**	**3-1-0**	**4**	**Dr S.Maitra & Dr K Basu**

Probability

Historical development of the subject and basic concepts, stochastic simulation, random numbers. **[2]**

Random variables and probability distributions, binomial and multinomial distribution, geometric distribution, hypergeometric distribution, normal distribution, gamma distribution, exponential distribution, negative binomial distribution. **[4]**

Simulations using Monte Carlo procedure, Buffon's needle problem, Two dimensional distribution, joint and marginal distribution, conditional distribution, random walks. **[5]**

Expected value and variance of a random variable, covariance, correlation. **[3]**

Distribution of sum of independent random variables, convergence of a sequence of random variables, convergence in distribution, convergence in probability, convergence in L^p, Tchebychev inequality, law of large numbers. **[6]**

Central limit theorem for Bernoulli trails, normal approximation to binomial, the general central limit theorem. **[2]**

Statistics

Basic Concepts, rule, Measures of Central Tendency, Measures of Dispersion, Tchebycheff's theorem & Empirical rule Measures of relative standing, some principles of statistical model **[4]**

Random Sampling & Methods of Sampling, Sampling Distribution & Standard Error, Sampling Distribution of the Sample Mean, Central Limit Theorem, Sampling Distribution of the Sample Proportion, sampling Distribution of the difference between two sample means and sampling Distribution of the difference between two sample proportions. **[5]**

Point Estimation, Interval Estimation, Confidence Interval, Large Sample Confidence Interval for a Population Mean μ, Large Sample Confidence Interval for a Population Proportion, estimating the difference between two Population means, estimating the Difference between two Binomial proportions, Maximum Likelihood Estimation. **[4]**

Statistical Hypotheses - general concepts, Large sample test about a population mean, Large sample test of Hypothesis for the Difference Between Two Population means, Large sample test for a Binomial proportion, Large sample test of Hypothesis for the difference between two Binomial proportions, Student's t-distribution, Small sample Inferences concerning a

population mean, Inferences for the difference between two means, Inferences concerning a population variance, F-distribution, Comparing two population variances. **[5]**

Linear Regression, Properties of the Least Square Estimators, Inferences concerning the Regression coefficients, Analysis of variance for Linear Regression, Testing the usefulness of the Linear Regression Model. **[5]**

TEXT BOOKS:

1. **William Mendenhall, Robert J. Beaver, B.M. Beaver,** *Introduction to Probability &Statistics*. Twelfth Edition, India Edition, Thomson.
2. **Gary Smith**, *Essential statistics, Regression & Econometrics*, Second Edition.
3. **C.Grinstead and J.Snell**, Introduction to probability, American Mathematical Society

REFERENCE BOOKS:

1. **Montgomery,** *Applied Statistics and probability for Engineers. Fourth Edition,*Wiley India Pvt Ltd.
2. **Ronald E Walpole, Sharon L Myers & Keying Ye,** *Probability& Statistics for Engineers &Scientists.* Eighth Edition, Pearson

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 1002	**Fundamentals of Operations Research**	**3-1-0**	**4**	**Dr S.S. Mondal & Dr A. Pal**

Overview of Operations Research: Origin of OR and its definitions, OR with special emphasis on interdisciplinary and system approach, Orientation-iconic, analogue and mathematical models **[3]**

Stages of OR development: Formulation of the OR problems, Developing OR models, Testing the adequacy of the model, Model solution, Evaluation of the solution and implementation. **[5]**

Linear Programming and its Applications: Vector spaces, Basis, Linear transformations, Convex sets, Extreme points and convex polyhedral sets Theory of Simplex method, Simplex Algorithm, Degeneracy, Duality theory, primal dual algorithms, Transportation problems, Assignment problems, Sensitivity analysis. **[15]**

Decision Analysis Modeling of decision Problems, Decision analysis under strict uncertainty: Preference orderings, Maximin rule, Minimax regret rule, Optimism -Pessimism rule, The Principle of Insufficient reasoning, Decision analysis under risk, Decision analysis without sampling, Decision analysis with sampling. **[10]**

Non-linear programming: Lagrangian function, NLPP with equality constraint, NLPP with inequality constraint, Kuhn-Tucker conditions, Quadratic programming, Convex Programming, Separable Programming. **[12]**

TEXT BOOKS:

1. Ravindran, Philips, Solberg, Operations Research Principles and Practices, Wiley India Edition.
2. J. K. Sharma: Fundamentals of Operations Research, Macmillan.

REFERENCE BOOKS:

1. H. A. Taha, Operations Research –An introduction, PHI
2. F.S. Hiller and G. J. Leiberman, Introduction to Operations Research (6th Edition), McGraw-Hill International Edition, 1995.
3. KantiSwarup, P. K. Gupta and Man Mohan, Operations Research- An Introduction, S. Chand & Company.
4. Anderson, D. R., Sweeney, D. J. and Williams, T. A., An Introduction to Management Science, St. Paul West Publishing Company, 1982.

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 1003	**Optimization Techniques**	**3-1-0**	**4**	**Dr K. Basu & Dr S.S.Mondal**

Extension of Linear Programming: Revised Simplex, Bounded Variables, Dual Simplex, Parametric Programming. **[10]**

Integer Programming: Branch and bound algorithm, Cutting plane methods for pure and mixed Integer programming problems, Knap-sack problem, travelling salesman problem. [5]

Dynamic Programming: Bellman's principle of optimality and recursive relationship of dynamic programming for various optimization problems. **[5]**

Deterministic Inventory Management

Concept of inventory and various inventory parameters, EOQ formula, EOQ with quantity discount, Multi-item Inventory and Multiple Constraints, Inventory with deterministic non-constant demand rate, Concept of Lead time, safety stock and service level. **[5]**

Game Theory: Maxmin and Minmax principle, two –person Zero-sum games with saddle point. Game problems without saddle point, Pure strategy, Solution of a 2 × 2 game problem without saddle point, Graphical method of solution for n ×2 and 2 ×n game problem, Reduction rule of a game problem(Dominance rule), Algebraic method of solution of game problem without saddle point, Reduction of a game problem to linear programming problem. Bimatrix games: LCP formulation, Lemke's salgorithm for solving bimatrix. **[10]**

Network Analysis: Introduction to network analysis, Shortest path problem, Construction of minimal spanning tree, Flows in networks, Maximal flow problems.

Definition of a project, Job and events, Construction of arrow diagrams, Determination of critical paths and calculation of floats. Resource allocation and least cost planning, Use of network flows for least cost planning. Uncertain duration and PERT, PERT COST system. Crashing, Updating (PERT and CPM). **[10]**

TEXT BOOKS:

1. **J.K.Sharma:***Operations Research- Theory and applications*. Macmillan.
2. **Ravindran, Philips, Solbery:** *Operations Research- Principals and practice*.John Wiley & Sons.

REFERENCE BOOKS:

1. **KantiSwarup, P. K. Gupta and Manmohan:** *Operations Research*. S.Chand& Sons.
2. **F.S.Hiller&G.J.Leiberman:** *Introduction to Operations Research*, GcGraw Hill.
3. **E.N.Barron**" *Game Theory an Introduction*" John wiley& sons publication.

Elective – I

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9011	**Programming Languages & Data Structures**	**3-1-0**	**4**	**Dr G. Panigrahi**

Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers, Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit Input & Output devices, Binary & Allied number systems representation of signed and unsigned numbers, BCD, ASII. Binary Arithmetic & logic gates, Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. **[8]**

C Fundamentals : The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements, Operators & Expressions : Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence and order of evaluation. Input and Output: Standard input and output, formatted output -printf, formatted input scanf, Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels, Fundamentals and Program Structures: Basic of functions, function types, functions returning , values, functions not returning values, auto, external, static and register variables, scope rules, recursion, function prototypes, C preprocessor, command line arguments, Arrays and Pointers: One dimensional arrays, pointers and functions, multidimensional arrays, Structures Union and Files: Basic of structures, structures and functions, arrays of structures, bit fields, formatted and unformatted files. **[10]**

Introduction to C++ programming

Classes and objects, Arrays of objects, Passing objects to member functions. Function, overloading, Friend functions, Passing objects to friend functions, Member functions/Friend functions returning objects, Pointer: Accessing data members and member functions using pointers, Constructors and Destructors: constructors, parameterized constructors, overloaded constructors, Copy constructors. **[10]**

Data Structures: Arrays, Stacks Queues, Searching & Sorting Algorithms **[8]**

Trees: Traversals in a tree (In order, Preorder & Post order), Binary Search tree, B^+tree, B tree **[9]**

TEXT BOOKS:

1. **V. Rajaraman,** *Computer Programming in C*, Prentice Hall India, 1994.
2. **Seymour Lipschutz " Data Structures"** McGraw-Hill 1986

REFERENCE BOOKS:

3. **E. Balagurusamy,** *Introduction to Computing*, TMH.
4. **F. S. Schied,** *Theory and Problems of Computers and Programming*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9012	**Advanced Mathematical Modelling**	**3-1-0**	**4**	**Dr S Maitra**

Basics of Mathematical Modelling : Elementary mathematical models; Role of Mathematics in problem solving;Concept of mathematical modeling; System approach; formulation, analysis ofmodels; Sensitivity analysis. **[4]**

Mathematical Modelling through ordinary differential equations: Linear growth and decay model, Nonlinear growth and decay models (Logistic lawof population growth). **[8]**

Mathematical Modeling through system of ordinary differential equations of first order: Mathematical modeling in population dynamic, Prey-Predator models, Mathematical modeling of epidemics, Compartmental Models, Mathematical modelling in Economics, Arms race, Medicine. **[10]**

Mathematical Modeling through Difference equations: Mathematical modeling in population dynamics and genetics, Mathematical modeling in Economics and Finacnce, Mathematicalmodeling in probability theory. **[8]**

Mathematical Modeling through partial differential equations: PDE model for birth-death immigration-emigration process, PDE model for astochastic epidemic process with no removal. **[8]**

Mathematical modeling through stochastic Differential Equations: Brownian motion and its properties, Ito formula, Ito integrals and its properties, Comparison between Ito and Stratonovich integrals. **[7]**

TEXT BOOKS:

1. J. N. Kapur, Mathematical Modeling, Wiley Eastern.
2. D. N. Burghes, Mathematical Modeling in the Social Management and Life Science, Ellis Horwood and John Wiley.

REFERENCE BOOKS:

1. B.K.Oksendal, Stochastic differential equations, An introduction with applications, 6th Edition, Springer, 2010

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9013	**Graph Theory and its Applications**	**3-1-0**	**4**	**Dr A. Pal**

Basic Concepts: Graphs and digraphs, Graph terminologies, Types of graphs, Bipartite graph, Isomorphism and subgraphs, Operations on graphs; Matrix representation of graphs (Adjacency and Incidence Matrices)**.** **[4]**

Graph Connectivity: Connected graphs and components; Walk, trial, path and circuits; Cut vertices, cut edges; bonds and blocks, Menger's theorem. **[4]**

Graph Traversibility: Euler trials and tours, Hamilton paths and cycles, theorems of Dirac, Ore, Bondy and Chvatal, The Chinese Postman Problem, The Travelling Salesman problem **[4]**

Trees and Fundamental circuits: Trees and forests; labeled tree; Cayley's formula; Binary tree; spanning tree; minimal spanning tree; Matrix-Tree theorem; Fundamental circuits; cutsets and cut vertices; fundamental cutsets. **[5]**

Matching and covering: Berge's Theorem; perfect matching (in both bipartite and general graphs); Hall's theorem; Independent sets and covering numbers. **[3]**

Planar and dual graphs: Euler's formula; Kuratowski's theorem; Combinational and geometric duals; Detection of planarity; Thickness and crossings. **[3]**

Graph Colorings: Chromatic number; Chromatic Polynomial; Vizing's theorem; Brooks theorem; Greedy algorithm; Welsh-Powell bound; The six and five color theorems; Four color Conjecture. **[4]**

Directed graphs: Types of digraphs; directed paths and cycles; Euler digraphs; Directed trees; connectivity and strongly connected digraphs; Arborescence; Tournaments, Acyclic digraphs and decyclication. **[3]**

Graph algorithms: Warshall's algorithm for directed graph; Tree traversal algorithms (DFS and BFS); Shortest path algorithms (Dijkstr's and Floyd's algorithm); Minimal Spanning tree algorithms (Prim's and Kruskal's algorithms); Huffman's Coding Algorithm. **[5]**

Network flows: Network flows and flows cuts, Max flow min cut theorem; Ford Fulkerson algorithm. **[3]**

Selected topics: Graph enumeration with Polya's theorem; Factorizations; Dominating sets; Intersection graphs; Perfect graphs; Random graph. **[4]**

TEXT BOOKS:

1. B. West Douglas, Introduction to Graph Theory,Prentice Hall
2. NarsingDeo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall.

REFERENCE BOOKS:

1. D Jungnickel,Graphs, Networks and Algorithms, Springer
2. Hartsfield and Ringel, Pearls in Graph Theory: A comprehensive Introduction, John Wiley
3. Bondy and Murty,Graph Theory with Applications, MacMillan.

Elective – II

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9014	**Fuzzy Logic and Fuzzy Decision Making**	**3-1-0**	**4**	**Dr S. Kar**

Basic concepts of fuzzy sets and fuzzy logic, Motivation, Fuzzy sets and their representations, Membership functions and their designing, Operations on fuzzy sets, Convex fuzzy sets, Alpha-level cuts, Geometric interpretation of fuzzy sets. **[10]**

Fuzzy extension principle and its application. **[2]**

Fuzzy numbers, Fuzzy numbers in the set of integers, Arithmetic operations on fuzzy numbers. **[6]**

Linguistic variables, Linguistic modifiers, Fuzzy rules, Fuzzy relations, Basic properties of fuzzy relations, Composition of fuzzy relations, Fuzzy reasoning. **[6]**

Fuzzy mapping rules and fuzzy implication rules, Fuzzy rule-based models for function approximation, Types of fuzzy rule-based models (the Mamdani, TSK, and standard additive models), Fuzzy implications and approximate reasoning. **[5]**

Fuzzy logic, Truth, Propositions of fuzzy logic, Fuzzy logic and probability theory, Possibility and Necessity, Possibility versus probability, Probability of a fuzzy event, Baye's theorem for fuzzy events, Probabilistic interpretation of fuzzy sets. **[6]**

Decision making in Fuzzy environment, Fuzzy Multi criteria analysis, Multistage decision making, Decision making using Fuzzy ranking methods, Fuzzy Linear programming, Fuzzy goal programming, Fuzzy Multi-objective decision making. **[10]**

TEXT BOOKS:

1. H. J. Zimmermann, Fuzzy Set Theory and its Applications: Second Edition,Kluwer Academic Publishers, Boston, 1991.
2. K. H. Lee, First Course on Fuzzy Theory and Applications, Springer, 2005

REFERENCE BOOKS:

1. W, Pedrycz, Fuzzy sets Engineering, CRC Press, 1995
2. G. J. Klir and T. A. Folger, Fuzzy sets, Uncertainty and Information, Prentice Hall,EnglewoodCliffs, 1988.
3. G. J. Klir, U. S. Clair and B. Yuan, Fuzzy Set Theory: Foundation andApplication, Prentice Hall, 1997.
4. G. Bojadzieve and M. Bojadzieve, Fuzzy Sets, Fuzzy Logic Applications, WorldScientific, 1995.

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9015	**Automata & Algorithms**	**3-1-0**	**4**	**Dr S. Kar & Dr G Panigrahi**

Fundamentals: Methods of Proof, Basic Concepts of Languages, Definitions and classification of Grammers, Alphabet, Strings, Languages, Finite Representation of Languages. **[5]**

Finite Automata (FA): Deterministic Finite State Automata,Non-deterministic Finite State Automata, Regular Expressions, Regular Grammer, Ambiguity of Regular Languages, Pumping Lemma for regular language, Myhill-NerodeTheorem.***Closure Properties of Regular Language*:** Closure under Boolean operations, reversal, homomorphism, inverse homomorphism, etc. Pumping lemma. **[7]**

Context Free Grammers (CFG): Pumping Lemma of Context Free Language (CFLs), ***Closure properties of CFL:*** closure under union, concatenation, Kleene closure, substitution, homomorphism, reversal, intersection with regular set, Normal Forms, Derivation trees and ambiguity. **[7]**

Pushdown Automata: Pushdown Automaton, Equivalence between acceptance by Final State, Equivalence of Context Free Grammer and Pushdown Automaton. **[5]**

Turing Machine (TM): Turing Machine as an Acceptor and as a Computing device, Techniques for Turing Machine construction, Equivalence between Turing Machine and Type 0 Language, The Halting problem.Context-sensitive languages, Recursive and Recursive Enumerable sets, Chomsky Hierarchy. **[6]**

Algorithms:

Analysis of Algorithms :Analysis of Algorithms, Asymptotic notations-big ohm, omega and theta. Average case analysis of simple programs like finding of a maximum of n elements. Recursion and its systematic removal. **[5]**

Design of Algorithms: (Divide and Conquer, Greedy method, Dynamic programming, Back tracking, Branch and Bound). Lower bound theory, Non – deterministic algorithm – Non – deterministic programming constructs. Simple non-deterministic programs. NP – hard and NP – complete problems. **[6]**

Different types of Algorithms: Quicksort – Non – recursive implementation with minimal stack storage. Sorting and Searching Algorithms, Interpolation and Binary Search. **[4]**

TEXT BOOKS:

1. Hopcroft, Ullman - "Introduction to Automata Theory, Languages and Computation", Pearson Education.
2. K.L.P. Mishra and N.Chandrasekaran, "Theory of Computer Science: Automata, Languages and Computation", PHI Learning Private Limited, Delhi India.

REFERENCE BOOKS:

1. Papadimitrou, C. and Lewis, C.L., "Elements of the Theory of Computation", PHI Learning Private Limited,Delhi India.
2. MichealSipser, "Introduction of the Theory and Computation", Thomson Learning.
3. J.Martin, "Introduction to Languages and the Theory of Computation", Third Edition, TMH, 2003.

Sessional – I

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 1051	Programming Lab	**0-0-4**	**2**	

C Language

Execution of Programs using the following: Decision Making andBranching- if statement, Nested if, Else if ladder, Block if, Switch statement.Decision Making and looping-while, do-while, for. Arrays- Traversing, Sorting,Searching, Inserting, Deleting operations; Processing Arrays with more than onedimension, Functions, Recursive functions, Nesting of Functions. Structures- Useof structure, Array of Structures, Unions, Handling Files in C- Sequential, randomaccess files. Use of Pointers, Linked Lists: Linear one-way linked list-Traversing,Insertion, Deletion and Searching operations. Use of Preprocessors: SimplePreprocessors- Macro substitutions, File inclusion directives.

TEXT BOOKS:

REFERENCE BOOKS:

Sessional – II

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 1052	Operations Research Lab	**0-0-4**	**2**	

The following problems are to be solved by using C/C++ language

1. Problems on LPP by Simplex Method
2. Problems on LPP by Revised Simplex Method
3. Problems on Integer Programming by Gomory's cutting plane method
4. Problems on Networking (PERT and CPM)
5. Problems on Inventory
6. Problems on Dynamic Programming
7. Problems on Monte Carlo Simulation
8. Problems on Queuing Theory
9. Problems on Bi-matrix games
10. Problems on QPP by Beals's Method and Wolfe's Method

TEXT BOOKS:

REFERENCE BOOKS:

Semester – II

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA -2001	**Advanced Operations Research**	**3-1-0**	**4**	**Dr K. Basu**

Queuing Theory: Introduction of Basic Concepts in Stochastic Processes. Markov Chain and Markov Processes. Introduction to waiting line models steady state behaviour of M/M/1 and M/M/C queueing systems, Erlangian Queueing Systems: $M/E_k/1$ and $E_k/M/1$. Bulk Queueing Systems. Basic idea of priority systems. Imbedded Markov chain models: M/G/l, G/M/l. **[12]**

Probabilistic Inventory Management: Single period inventory models, newspaper boy problemswith or without salvage value, Periodic and Continuous review models, Inventory management of items with deterioration, Inventory management of items with inflation. **[8]**

Replacement, Reliability & Maintenance: Replacement of items that deteriorate, Equipments that suddenly fail, chain of improving equipments, assuming (1) same life for each member in thechain and (2) increasing life, equal to that of deterioration only at infinity. Replacement of items that fail stochastically-individual and common preventive replacements.

Basics of reliability classes of life distributions based on notions of ageing, Reliability models of non-maintained & maintained systems, Availability theory and it's modelling for various configurations. **[12]**

Sequencing Analysis: Two machine and n jobs (no passing) problem and three machine and n jobs (no passing) problems: different routing, 2 jobs and m machines, n jobs and m machines, branch and bound algorithms. **[6]**

Simulation: Implementation of simulation modeling, Design of simulation models.

Generation of random deviates, the uniform distribution and its importance to simulation, Generation of random numbers (Properties of uniformly distributed numbers, Mid-square technique, Mid-product, technique, Fibonacci method).

Generating uniform random variates via a congruential method (Mixed method, Multiplicative method, Quadratic congruential method), testing a random number generator (Frequency test, Gap test, Runs test, Poker test).

Inverse transform method, (Exponential distribution, Weibull distribution, Geometric distribution), Rejection Techniques (Beta distribution, Gamma distribution), Composition method (Poisson distribution, Erlang distribution, Binomial distribution), Approximation techniques, Special probability distributions (Chi-square distribution, Student's T-distribution, F-distribution). **[7]**

TEXT BOOKS:

1. **Prem Kumar Gupta & D. S. Hira,** *Operations Research*, S Chand publication
2. **N.D.Vohra**, *Quantitative techniques in management*, Mc Graw hill.

REFERENCE BOOKS:

1. **Ravindran, Phillips and Solberg,** *Operations Research – Principles & Practice*, John Wiley &Sons
2. **F. S. Hiller & G. J. Leiberman,** *Introduction to Operations Research.* McGraw hill.

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 2002	**Advanced Optimization Techniques**	**3-1-0**	**4**	**Dr K. Basu**

Goal Programming: Concept of goal programming, Modeling Multiple objective problems, Goal programming model formulation (Single goal with multiple sub goals, equally ranked multiple goals, Priority ranked goals, General goal programming models), Graphical method of goal programming, Simplex method in goal programming. Post optimality analysis. **[6]**

Stochastic Programming: Stochastic programming with one objective function. Stochastic linear programming. Two stage programming technique. Chance constrained programming technique, Stochastic dynamic programming. **[8]**

Geometric Programming: Posynomial; Unconstrained GPP using differential Calculus; Unconstrained GPP using Arithmetic – Geometric Inequality; Constrained GPP. **[8]**

Scheduling: PERT and CPM with activity times known and probabilistic. Various types of floats, Updating of PERT charts. Project crashing. Formulation of CPM as a linear programming problem. Resource leveling and resource scheduling. **[7]**

Search and Heuristic Methods: Introduction and Overview of Heuristic and Meta-Heuristic Search: General optimization problems, Fitness functions, Local search vs. Meta-heuristic search, Combinatorial algorithms for generic data structures, Visualization of the Search Landscape.Specific Search Algorithms: Hill Climbing, Simulated Annealing, Tabu Search, Genetic Algorithms, Ant Colony Optimization. **[16]**

TEXT BOOKS:

1. **A. Ravindran, K. M. Ragsdell and G. V. Reklaitis**, *Engineering Optimization-Methods and Applications, Wiley-India Edition.*
2. **Singiresu S. Rao,** *Engineering Optimization -Theory and Practice, New Age International (P) Limited.*

REFERENCE BOOKS:

1. **R. Fletcher,** *Optimization,* Academic Press, 1969.
2. **D. G. Luenberger,** *Introduction to Linear and Nonlinear Programming,* AddisonWesley,1973.
3. **Z.S. Kambo**, *Mathematical Programming Techniques*, East West Press, 1997

Elective – III

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA-9016	**Information and Coding Theory**	**3-1-0**	**4**	**Dr L. K. Dey & Dr. S. Bagchi**

Source Coding: Introduction to Information Theory, Uncertainty and Information, Average MutualInformation and Entropy, Information Measures for Continuous Random Variableand Information Rate. **[6]**

Introduction to Coding Theory: Basic Assumptions, Correcting and Detecting Error Pattern, the Effects of ErrorCorrection and Detection, Finding the Most Likely Codeword Transmitted. SomeBasic Algebra, Weight and Distance, Maximum Likelihood Decoding (MLD),Reliability of MLD, Error-Detecting Codes, Error-Correcting Codes. **[10]**

Linear Codes: Linear Codes, Linea spaces over finite field, Independence, Basis and Dimension, Matrices, Bases for C= <S>and $C^{\perp}$, Generating Matrices and Encoding, Parity-Check Matrices, EquivalentCodes, Distance of a Linear Code, Cosets, MLD for Linear Codes. **[10]**

Finite Fields: Finite Fields: the basic theory, Field Extension: a brief idea, Irreducible

Polynomial and how to find irreducible polynomial, The number of irreduciblepolynomials, Introductory idea of Vector Spaces, Minimal Polynomial, Theautomorphisms Group of GF(pm) and Bases of GF(pm) over GF(p). **[8]**

Perfect and Related Codes: Some Bounds for Codes, Perfect Codes, Hamming Codes, Extended Codes, theExtended Golay Code, Decoding the Extended Golay Code, Reed-Muller Codes. **[8]**

Cyclic Linear Codes: Polynomials and Words, Introduction to Cyclic Codes, Finding Cyclic Codes, Dual Cyclic Codes. **[4]**

TEXT BOOKS:

1. *S. Ling, C. Xing,,*Coding Theory-A first course, *Cambridge University Press, 2004.*

REFERENCE BOOKS:

1. D.R. Hankerson, D. G. Hoffmann, D. A. Leonard, C.C. Lindner, K.T. Phelps, C.A. Rodger, J.R. Wall: ***Coding Theory and Cryptography,*** CRC-234.
2. F. J. Macwilliams, N. J.A. Sloane: ***The Theory of Error Correcting Code***, North-Holland.
3. Roman, S.: ***Coding and Information Theory,*** New York: Springer-Verlag, 1992.

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA-9017	**Soft Computing**	**3-1-0**	**4**	**Dr S. Kar**

Introduction of Soft Computing, Concepts and applications. **[4]**

Biological and artificial neuron, Neural networks, Adaline, Perceptron, Madaline and BP (Back Propagation) neural networks, Adaptive feedforward multilayer networks, RBF and RCE neural networks, Topologic organized neural networks, competitive learning, Kohonen maps, Solving optimization problems using neural networks, Stochastic neural networks, Boltzmann machine. **[15]**

Fuzzy sets, fuzzy logic and fuzzy inference, fuzzy decision-making. **[5]**

Genetic algorithms, Probabilistic reasoning, Rough sets. **[8]**

Ant colony optimization and Particle swarm optimization. **[6]**

Hybrid approaches (neural networks, fuzzy logic, genetic algorithms and rough sets), Engineering optimization problem solving using genetic algorithm, Neural network approaches, fuzzy and rough approaches. **[7]**

TEXT BOOKS:

1. D. K. Pratihar, Soft Computing, Narosa, 2008.
2. D. E. Goldberg, Genetic Algorithms in Search, Optimization and Machine learning, Pearson Education, Inc. 1989.

REFERENCE BOOKS:

1. S.N. Sivanandam and S. N. Deepa, Principles of Soft Computing, Wiley, 2012.
2. M. Dorigo and T. Stutzle, Ant Colony Optimization, Prentice Hall India Pvt. Ltd, 2005.
2. E. Bonabeau, M. Dorigo and G. Theraulaz, Swarm Intelligence: From Natural to Artificial Systems, New York, Oxford University Press, 1999.

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA-9018	**Financial Mathematics**	**3-1-0**	**4**	**Dr S Maitra**

Basics about stock market, investment and securities, stock return, risk, option and futures**.[6]**

Weiner process and its properties, Markov property, Martingale property. **[8]**

Stochastic differential equations: Ito Calculus, one dimensional diffusion process, Multidimensional diffusion process, Poisson Process. **[10]**

Black Scholes 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. **[10]**

Binomial Methods: option valuation, dividend paying stock, general formulation and implementation. **[3]**

Finite difference methods: explicit and implicit methods, stability and convergence, finite difference methods for Black-Scholes PDE. **[6]**

Monte Carlo Simulation: valuation by simulation. **[2]**

TEXT BOOKS:

1. **D.G. Luenberger,** *Investment science,* Oxford University Press.
2. **B. Oksendal,** *Stochastic Differential Equations,* Springer-Verlag.

REFERENCE BOOKS:

3. **Lishang Jiang,** *Mathematical modelling and methods of option pricing,* World Scientific.

Elective - IV

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA-9019	**Advanced Discrete Mathematics**	**3-1-0**	**4**	**Dr S. Kar & Dr G Panigrahi**

Introduction to Combinatorics, Counting techniques, The inclusion-exclusion principle, The pigeon-hole principle and its applications, Recurrence relation, Generating function. **[10]**

Mathematical logic, Propositional calculus, Basic logical operation, Truth tables, Notion of interpretation, validity, consistency and completeness. **[6]**

Propositional Calculus: Well-formed formulas, Tautologies, Equivalence, Normal forms, Truth of algebraic systems, Calculus of predicates. **[6]**

Relations, Equivalence relation, Diagraphs, Computer representation of relations,Warshall's algorithm. **[8]**

Lattice Theory and Boolean Algebra. Functions, Composition of function, functions for computer Science, Permutation function and growth of functions. **[10]**

Graph Algorithms. **[5]**

TEXT BOOKS:

1. J.P. Tremblay and R.P. Manohar, Discrete Mathematics with Applications toComputer Science, McGraw Hill, 1989.
2. Kenneth H. Rosen, Discrete Mathematics and its Applications, McGraw Hill, 7th Edition.

REFERENCE BOOKS:

1. D.S. Malik & M.K. Sen, Discrete Mathematical Structures– Theory & Applications, Thomson India Edition.

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9020	**Advanced Statistical Analysis**	**3-1-0**	**4**	**Dr K. Basu**

Multivariate Analysis: Basic concepts, Measurement scales, Measurement error and Multivariate Measurement, Classification of Multivariate Techniques, Types of Multivariate Techniques, Structured Approach to Multivariate Model building **[2]**

Examining Data for Multivariate Analysis: Bivariate Profiling, Multivariate Profiles, Missing Data, Outliers, Detecting and Handling Outliers, Testing the assumptions of Multivariate Analysis **[2]**

Multivariate Normal Distribution: Multivariate Normal Density & its properties**,** Sampling from a multivariate Normal Distribution and maximum Likelihood estimation, sampling distribution of mean & standard deviation, Detecting outliers ,Transformation to near Normality. **[5]**

Principal Component Analysis: Population Principal Components, Principal components for covariance matrices with special structures, Sample Variation by Principal Components, Large sample inferences, monitoring quality with Principal components. **[10]**

Factor analysis: What is Factor analysis, Objectives of Factor analysis, designing a Factor analysis, Assumptions in Factor analysis, Deriving factors and assessing overall fit, 3 process factor interpretations, Validation of Factor Analysis. **[6]**

Multiple Discriminant Analysis and Logistic Regression: What are Discriminant Analysis and Logistic Regression, Objectives of Discriminant Analysis, assumptions of Discriminant Analysis, estimation of the Discriminant Model and assessing overall fit, Logistic Regression: Regression with a binary dependent variable **[10]**

Cluster Analysis: What is cluster analysis, Objectives of cluster analysis, Assumptions of cluster analysis, deriving clusters and assessing overall fit, Interpretation of the clusters, hierarchical & non-hierarchical clustering techniques. **[10]**

TEXT BOOKS:

1. **J.F. Hair, W.C. Black, B.J. Babin, R.E. Anderson, R.L. Tatham,** *Multivariate Data Analysis,* Pearson Education.
2. **R. A. Johnson, D. W. Wichern,** *Applied Multivariate Statistical Analysis,* Pearson Education.

REFERENCE BOOKS:

1. **W. Hardle, L. Simar,** *Applied Multivariate Statistical Analysis,*Springer.
2. **T.W. Anderson**, *An introduction to multivariate statistical analysis*, Wiley student edition.

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9021	**Decision Theory**	**3-1-0**	**4**	**Dr S S Mondal**

Randomization, Optimality, Bayes rules, Minimax rules, Admissiable rules, Invariance and sufficiency, Complete class and essential complete class of rules. **[8]**

Decision analysis under Risk-Probability: Decision analysis without sampling, Decision analysis with sampling. **[5]**

Decision Analysis under Risk Utility: St. Petersburg Paradox. Construction of Utility Functions, Risk Attitudes. **[5]**

Decision Trees and Sequential Decision Making **[4]**

Multi-criteria decision methods **[6]**

Multi-objective optimization: Lexicographic optimality, Interactive procedures, efficient and properly efficient solutions. **[6]**

Data Envelopment Analysis: Chames, Cooper and Rhodes (CCR) model. Banker, Charnes and Cooper (BCC) model. **[5]**

Analytic Hierarchy Process: Ranking and weighting information using Eigen Vector Method (EVM) and Approximation Methods. **[6]**

TEXT BOOKS:

1. **Martin Peterson,** *An Introduction to Decision Theory,* Cambridge University Press 2009.
2. **ItzhakGilboa,** *Theory of Decision under Uncertainty,* Cambridge University Press. 2008.

REFERENCE BOOKS:

1. **Giovanni Parmigiani, Lurdes Inoue,** *Decision Theory: Principles and Approaches,* Wiley, 2009.

Elective V

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9022	**Cryptology**	**3-1-0**	**4**	**Dr S. Bagchi**

Pre-requisites: Modern algebra.

Secure communications, shift ciphers, affine ciphers, vigenere cipher, symmetric key, public key, block ciphers (DES, AES), Shannon's Notion of perfect secrecy, one time pads, secure random bit generator, linear feedback shift register sequences, stream ciphers (LFSR based, RC4), Block cipher modes of operations. **[15]**

Differential cryptanalysis, Linear cryptanalysis. **[7]**

Prime number generation, RSA, attack on RSA, Diffie-Hellman key exchange, El Gamal public key cryptosystem, cryptographic hash function, RSA signature, El Gamal signatures, hashing and signing, digital signature algorithm. **[8]**

Elliptic Curves, Basic facts. Elliptic curve cryptasystems. **[8]**

One-way functions, PRG, PRP. **[7]**

TEXT BOOKS:

1. **J Hoffstein, J Pipher, J H Silverman,** An introduction to Mathematical Cryptography, 2e, Springer, 2014.
2. **D R Stinson,***Cryptography: Theory and Practice.* CRC Press. 2006.

REFERENCE BOOKS:

1. **Johnnes A Buchmann,** *Introduction to Cryptography,* Springer, 2001.
2. **W Trappe and L C Washington,** *Introduction to Cryptography with coding Theory,* Prentice-Hall, 2006.
3. **Richard J. Spillman,** *Classical and Contemporary Cryptology,* Prentice Hall, 2005.

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9023	**Numerical Methods**	**3-1-0**	**4**	**Dr S.S.Mondal**

Finite Difference and Interpolation: Symbolic operators and their relations, Difference table, Central difference formulae of Gauss, Stirling formula, Bessel formula, Cubic spline interpolation. **[5]**

Approximation of function: Curve fitting by least square method (linear, polynomial, geometric), Chebyshev polynomial and Minimax property, Use of orthogonal polynomials, Gram-Schmidt orthogonalization method, Economization of power series. **[4]**

Numerical integration: Newton-Cotes formulae-open type and closed type,Romberg integration, Gaussian quadrature: Gauss-Legendre and Gauss-Chebyshevquadratures, Comparison of Newton-Cotes and Gaussian quadratures. **[5]**

Solution of non-linear equations: Roots of a polynomial by Birge-Vieta method, Graeffe's root squaring method, System of non-linear equations: fixed point method and Newton-Raphson methods, Convergence and rate of convergence. **[6]**

Solution of a system of linear equations: Matrix inversion method by partial and complete pivoting, LU decomposition method, Solution of tri-diagonal system of equations, Ill-conditioned linear systems, Relaxation method. **[7]**

Eigenvalue problem: Power method to find largest eigen value of eigen vector, Jacobi's method to find eigen values and eigen vectors of a symmetric matrix. **[4]**

Solution of ordinary differential equation: Taylor's and Euler's method, Runge-Kutta method of second and fourth order, Runge-Kutta method to solve a system of equations, Single step and multi-step methods, Predictor-corrector method: Milne's method, Adam's method, Solution of boundary value problems by finite difference method, Stability analysis. **[8]**

Partial differential equation: Finite difference scheme, Parabolic equation: Crank-Nicolson method, Elliptic and hyperbolic equations: iteration method. **[6]**

TEXT BOOKS:

1. **J.H. Mathews & K.D. Fink,** *Numerical Methods, Prentice Hall*
2. **M.K. Jain, S.R.K. Iyengar & R.K. Jain**, *Numarical Methods, New Age International Publishers.*
3. **S. S. Sastry,** *Introductory Methods of Numerical Analysis, PHI*

REFERENCE BOOKS:

1. **C. Butcher,** *Numerical Methods for Ordinary Differential Equations, Wiley*
2. **J.B. Scarborough**., *Numerical Mathematical Analysis, Oxford and IBH publishing co.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9024	**Reliability Theory**	**3-1-0**	**4**	**Dr K Basu**

Definition of reliability and its measures, concept of failure. General provision of a reliability specification, Methods of achieving reliability, Broad functions of reliability. [3]

Bath tub curve, causes of early failure and methods to avoid them, failure distributions: exponential, Weibull, truncated normal, log normal, gamma, inverse Gaussian, their properties and uses. [4]

Time dependent reliability of components and system- Failure rate versus time curve, modelling of failure rate, estimation of failure rates from empirical data, mean time to failure(MTTF), Reliability & hazard functions for different distribution, expected residual life, Series, parallel and r-out of n configurations; their block diagram. [6]

Problem of life testing, estimation of parameters and reliability using standard probability models using complete and censored (type I, II and III) samples, properties of these estimators. Probability plotting and graphical procedures for estimating the parameter and testing validity of model by some standard statistical tests. Life test acceptance sampling plans in exponential case. Sequential life test in exponential case, accelerated life test. [10]

Problem of optimal design of plan under Bayesian consideration, truncation of number of failure and cost model based on cost of sampling, testing and decision of acceptance and rejection, sign regular function and monotone plan, posterior risk and minimisation of expected regret. [6]

Reliability based optimum design- Introduction, Formulation of optimization problem, solution techniques. [6]

Failure modes, event tree & fault tree analysis-system safety analysis, Failure modes & effects analysis, Event tree analysis, Fault tree analysis. Minimal cut sets. [10]

TEXT BOOKS:

1. **S.S. Rao**, *Reliability engineering*, Pearson Publication.
2. **Bazvosky, I., Prentice Hall,** *Reliability Theory and Practice,* New Jersey.

REFERENCE BOOKS:

1. **Gertsbakh, I.B.,** *Statistical Reliability Theory,* Marcel Dekker Inc.
2. **Sinha, S.K.,** *Reliability and Life Testing,* Wiley Eastern Limited.
3. **Polvko, A.M.,** *Fundamentals of Reliability Theory,* Academic press, New York.
4. **Barlow, R.E. and Proschan, F,** *Mathematical Theory of Reliability,* John Wiley, New York.
5. **Gnedenko, Yu, Belyayev K and Solovyev, A.D.,** *Mathematical Methods of Reliability Theory,* Academic Press, New York.

Sessional - III

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 2051	**Computing Lab**	**0-0-4**	**2**	
TEXT BOOKS:				
REFERENCE BOOKS:				

A. MATLAB as a Programming Environment

1. Introduction

Editor, Debugger, Simulink, Web resources, Toolboxes

2. Function Minimization and parameters search

Polynomial fit: 1D and 2D fits, Data windowing, Error bounds. Arbitrary function fit: Error function, Fixing parameters. Goodness of fit: Bi criteria, Error in parameters.

3. Dataflow in Matlab

Data types: Matrix, string, cell and structure ; Creating, accessing elements and manipulating of data of different types. File Input-Output: Matlab files, Text files, Binary files, Mixed text-binary files. Communication with external devices: Serial port, Parallel port, Sound card, Video input.

4. Numerical Methods and Applications

Roots of equations: Algebraic and transcendental equations, System of linear equations, Application. Differential equations: Methods: _ Euler, _RK (ODE45), _ SIMULINK.

B. PROBABILITY AND STATISTICS LAB

1. Computation of various measures of central tendency, dispersion, skewness and kurtosis.
2. Fitting of binomial, Poisson, Normal distributions.
3. Computation of correlation coefficient, multiple and partial correlation coefficient, rank correlation.
4. Determination of regression lines and plane of regressions.
5. Computation of correlation coefficient for bi-variate data.
6. Computation of estimates based on various properties, computation of interval estimates.
7. Practical based on:
   I. test of hypothesises: one population and two population cases

   II. test of correlation and regression coefficients

   III. paired t-test

   IV. contingency table

   V. test of goodness of fit.
8. Practical based on analysis of variance