Rashtrasant Tukadoji Maharaj Nagpur University

Post Graduate Teaching Department of Mathematics (Autonomous)

Syllabus for M.Sc. (Mathematics) Program

Choice Based Credit System: Semester Pattern

(As per NEP-2020)

From the Session 2023-24 onwards

Rashtrasant Tukadoji Maharaj Nagpur University

Post Graduate Teaching Department of Mathematics

Syllabus for Two Years (Four Semesters) M.Sc. (Mathematics) Program
(NEP-2020)

Introduction:

The department has academic autonomy, which aimed to provide an opportunity to the department to add new, innovative, and need-based courses in the syllabus. So that, it can widen the mathematical knowledge of the students as well as the awareness of applications of Mathematics in various fields. The M.Sc. (Mathematics) program includes four semesters for the duration of two years the program contains theory as well as applied courses. M.Sc. Mathematics is the program, which laid the foundation of the career of a student. Hence, it is necessary to include the topics (courses) in this program, which can open the entry of students to various career options. Due to this, the present syllabus is framed with consideration of this aspect. The framework of this syllabus includes core courses, elective courses, and one computer skill course per semester. To prepare the students for quality research in mathematics the courses like research methodology and research projects are introduced. The course like on job training provides the opportunity for students to gain on field experience. The elective courses are framed to fulfill the demand of various fields such as data handling, data analysis, industry-based mathematics, system solutions etc., and skill-based courses provide an opportunity to develop a computer platform. Accordingly, one can look for opportunities in the industrial sectors, government sectors, and academic organizations after completion of this program. This syllabus provides an opportunity for the students to gain advanced knowledge of core mathematics, understand the applications of mathematics in different fields, and achieve computer skills to handle mathematical software. The combination of core mathematics and computer skills will provide a platform to open windows of employment. The Course Study and Scheme of Examination are given in Table I.

Eligibility:

For admission to the M. Sc. Semester I in Mathematics, a candidate shall have offered Mathematics as one of the subjects at the qualifying B.Sc. Examination with not less than 50% of aggregate marks (45% in case of a student from a reserved category) or equivalent CGPA from any of the recognized universities. However, the student who has completed four-year B. Sc. course [B. Sc. (Honours) as per NEP- 2020] with Mathematics (or allied subject) as the major subject with not less than 50% of aggregate marks (45% in case of a student from reserved category) or equivalent CGPA from any of the recognized university is eligible to enroll directly in semester III of M. Sc. (Mathematics) course. The department may conduct an entrance examination to admit the candidates to this program if needed.

Credits:

The total credits of the program are 88. One credit for theory/tutorial will be of 1 hr and that of practical will be of 2 hrs per week, running for 15 weeks. One credit will be equivalent to 15 clock hours of teacher-student contact in a semester. For detail, please see Table I-IV.

Offering Elective Course:

An elective course shall run through classes only if minimum 10 students register for it in a regular semester. However, students will have choice to opt the subject of his/her own interest from the list at their own. Students have to inform HOD for the opted elective course at the commencement of the semester. The students can opt either the elective course taught in the department in offline mode or any other equivalent online course of at least 4 credits offered by MOOC or any other such platform. The equivalence of such courses will be decided

by the departmental committee comprising of the faculty members of the department and chaired by the Head, Dept. of Mathematics. The student should get the equivalence letter of the course from this committee before enrolling for the course. The student should submit the passing certificate to the Head of the Department in order to include the marks in the mark sheet. The MOOCs which is identical to courses offered at PGTD Mathematics (in terms of contents) and are accessible to the student shall not be allowed for credit transfer.

Evaluation:
The evaluation of the student will be done according to the performance of components End Semester Examination (ESE) and Continuous Internal Assessment (CIA) where the weightage distribution for each course is 60% and 40% respectively for theory examination while for practical it is taken 50% of external and 50% of internal examination. For detail, please see Table I-IV. Successful examinees at the end of M. Sc. Sem-IV Examination who obtained CGPA above 7.51 shall be placed in First Division with distinction, those obtaining CGPA from 6.00 to 7.50 shall be placed in First Division, those obtaining CGPA from 4.50 to 5.99 shall be placed in Second Division and those obtaining CGPA from 4.00 to 4.49 shall be placed in Third Division.
In general, the percentage marks = CGPA x 10. Grades will be awarded as per university rules.

Internal Assessment:
The concerned teacher will award the internal assessment marks. Immediately after the assessment, the marks will be sent to the university in the prescribed format. The internal assessment marks will be awarded based on home assignments, unit test performance, seminars, practical performance, participation in the departmental activities (Popularization of Mathematics, study tour, industrial visits, visit to educational institutions and research organizations, fieldwork, group discussions or any other innovative practice) and attendance of the student throughout the session.

General Guidelines for Internal Assessment:

a) The internal assessment marks assigned to each theory paper as mentioned in the examination scheme.
b) There shall be one to three assignments per theory paper.
c) There shall be no separate/extra allotment of workload to the teacher concerned. He/She shall conduct the internal assessment activity during the regular teaching days/periods as a part of regular teaching activity.
d) The concerned teacher/the department shall keep the record of all the above activities until six months after the declaration of the results of that semester.
e) At the beginning of each semester, every teacher shall inform his/her students unambiguously the method he/she propose to adopt and the scheme of marking for internal assessment.
f) Teacher shall announce the schedule of activity for internal assessment in advance in consultation with Head of the Department.
g) Final submission of internal marks to the University shall be done with the marks of End Semester Examination (Theory).
h) Practical Examination:
Each practical carries 50 marks. For the examination, the distribution of the marks shall be as follows:
   1. Record/Journal/Internal assessment: 25% marks – Evaluated by Internal
   2. Practical Performance : 50% marks – Evaluated jointly by External and internal
   3. Viva-voce: 25% marks - Evaluated by External

NOTE:

1. Practical performance shall be jointly evaluated by the External and Internal Examiner. In case of discrepancy, the External Examiner's decision shall be final.
2. Practical exam shall be of 2 hours duration for one or two days, depending on subject and number of students.
3. The Practical Record of every student shall carry a certificate as shown below, duly signed by the teacher-in-charge and the Head of the Department.
4. If the student fails to submit his/her certified Practical Record duly signed by the Teacher-In Charge and the Head of the Department, he/she shall not be allowed to appear for the Practical Examination and no Marks shall be allotted to the student.
5. The certificate template shall be as follows:

C E R T I F I C A T E

Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Post Graduate Teaching Department of Mathematics

This is to certify that this Practical Record contains the bonafide record of the Practical work of Shri/Shrimati/Kumari _ of M. Sc. (Mathematics) Semester _ _ _ _ _ _ _ _ during the academic year _ _ _ _ _ _ _.
The candidate has satisfactorily completed the experiments prescribed by the department for the course _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Dated _ _ _ / _ _ _ / _ _ _ _ _

Signature of the concerned teacher Head of the Department

i) **Project Examination**:
The project work will carry a total of 100 marks for minor projects and 150 marks for major projects and will be evaluated by both external and internal examiners in the Department. The examiners will evaluate the project work considering the coverage of the subject matter, presentation, literature etc.

Work	Minor Marks	Major Marks	Evaluation
For written Project work	40	60	Evaluated jointly by External and Internal
For Presentation	20	30	Evaluated jointly by External and Internal
For Viva-Voce	20	30	Evaluated by External Examiner
Internal Assessment	20	30	Evaluated by Internal Examiner
Total	100	150	

Teacher and research project supervisor:
In addition to the regular teachers appointed in the department, these courses can be taught by a person having a post-graduate degree in Mathematics or any other relevant/equivalent subject or having research experience in that particular area. The regular full-time teacher of the department/Contractual teacher/contributory teacher approved by the university/ scientist of government or private research laboratory appointed by the university as a contributory teacher and having M.Phil./Ph.D. degree in Mathematics or any other relevant/equivalent subject can supervise the research project of the student.

The vision statement of the Department

To endeavor for Excellence Innovation and Professionalism Along with Sensibility, Kindness and Compassion.

The Mission of the Department

1. To develop decision-making capacity and to enable the youngsters to explore their own capabilities.
2. To achieve innovations in teaching, learning, research, and extension.
3. To promote academic excellence in professional qualifications laced with technical skills.
4. To equip and empower students with relevant knowledge and competence to face global challenges.
5. To inculcate creative, critical, and analytical thinking.
6. To produce committed and better citizens and professionals, rich in values and excellence, with a promising future.
7. To preserve our own cultural & humanistic values with the same ease as to adopt new technological expertise.
8. To develop personal human qualities like responsibility, sociability, self-management, self-esteem & integrity.
9. To infuse a competitive and fighting spirit among the students.

Program Outcomes (PO)

PO1 Self-Directed Learning: *Work independently to explore new ideas and solutions to mathematical problems*

PO2 Reflective Thinking: *Identify the importance of the information provided in theorems, axioms, and problems for further justification and application*

PO3 Professional Skills: *Explain/ demonstrate accurate and efficient use of advanced Mathematical techniques*

PO4 Digitally literacy: *Have sound knowledge of mathematical modelling, programming and computational techniques as required for research or employment in industry*

PO5 Lifelong learning: *Continue to acquire mathematical knowledge and skills appropriate to professional activities*

PO6 Leadership Quality: *Listen and understand the ideas and suggestions of others to improve quality of learning*

PO7 Ethical and Social awareness: *Capable of demonstrating the ethical issues related with the Intellectual Property Rights, copyright etc. and demonstrate highest standards of ethical issues in mathematics*

PO8 Team Work: *Participate constructively in classroom discussion*

PO9 Communication Skills: *Effectively communicate and explore ideas of mathematics for propagation of knowledge and popularization of mathematics in society*

Program Specific Outcomes (PSO)

PSO1 Disciplinary Knowledge: *Understand the basic and advanced concepts of Mathematics.*

PSO2 Problem Solving: *Identify and apply the most effective method to solve the problem within a stipulated time.*

PSO3 Analytical and Scientific Reasoning: *Think logically and analytically over the information and analyze it effectively.*

PSO4 Critical Thinking: *select the proper methodology to evaluate the mathematical problem for best outcome.*

PSO5 Research related skills: *Pursue research in challenging areas of pure/applied Mathematics to develop innovative technology as new creation.*

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Table I: Scheme of Teaching and Examination for First Semester M.Sc. Mathematics Program
Session 2023-24 onwards

Course Category	Code	Title of Course	Teaching			Examination Scheme					
							Maximum Marks				
			Theory	Practical/Project	Total	Duration (hrs.)	End Semester Examination (ESE)	Continuous Internal Assessment (CIA)	Maximum Total Marks	Minimum Passing Marks	Credits
Mandatory	MMT1T01	Algebra	4	--	4	3	60	40	100	50	4
	MMT1T02	Topology	4	--	4	3	60	40	100	50	4
	MMT1T03	Ordinary Differential Equations	4	--	4	3	60	40	100	50	4
	MMT1L04	Practical 1: C-Programming	--	4	4	2	25	25	50	25	2
Elective 1	**Select any one**										
	MMT1E05	Mathematical Statistics	4	--	4	3	60	40	100	50	4
	MMT1E06	Fuzzy Mathematics									
	MMT1E07	Applied Combinatorics									
	MMT1E08	Integral Equations									
	MMT1O09	Equivalent MOOC Course									
Research	MMT1T10	Research Methodology in Mathematics	2	--	2	2	30	20	50	25	2
	MMT1L10	Practical 2: Research Methodology in Mathematics		4	4	2	25	25	50	25	2
		Total	18	08	26	--	320	230	550	275	22

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Table II: Scheme of Teaching and Examination for Second Semester M.Sc. Mathematics Program Session 2023-24 onwards

Course Category	Code	Title of Course	Teaching			Examination Scheme					
							Maximum Marks				
			Theory	Practical/Project	Total	Duration (hrs.)	End Semester Examination (ESE)	Continuous Internal Assessment (CIA)	Maximum Total Marks	Minimum Passing Marks	Credits
Mandatory	MMT2T01	Real Analysis	4	--	4	3	60	40	100	50	4
	MMT2T02	Fluid Dynamics	4	--	4	3	60	40	100	50	4
	MMT2T03	Partial Differential Equations	4	--	4	3	60	40	100	50	4
	MMT2L04	Practical 3: R-Programming	--	4	4	2	25	25	50	25	2
Elective 2	**Select any one**										
	MMT2E05	Design of Experiments	4	--	4	3	60	40	100	50	4
	MMT2E06	Linear Programming									
	MMT2E07	Advanced Discrete Mathematics									
	MMT2E08	Linear Algebra and Differential Equations									
	MMT2O09	Equivalent MOOC Course									
Research	MMT2L10	Practical 4: On Job Training	--	8	8	2	50	50	100	50	4
		Total	16	12	28	--	315	235	550	275	22

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Table III: Scheme of Teaching and Examination for Third Semester M.Sc. Mathematics Program Session 2023-24 onwards

Course Category	Code	Title of Course	Teaching			Examination Scheme					
							Maximum Marks				
			Theory	Practical/Project	Total	Duration (hrs.)	End Semester Examination (ESE)	Continuous Internal Assessment (CIA)	Maximum Total Marks	Minimum Passing Marks	Credits
Mandatory	MMT3T01	Complex Analysis	4	--	4	3	60	40	100	50	4
	MMT3T02	Functional Analysis	4	--	4	3	60	40	100	50	4
	MMT3T03	Advance Numerical Methods	4	--	4	3	60	40	100	50	4
	MMT3L04	Practical 5: Programming with Python	--	4	4	2	25	25	50	25	2
Elective 3	**Select any one**										
	MMT3E05	Non-parametric Methods and Multivariate Analysis	4	--	4	3	60	40	100	50	4
	MMT3E06	Inventory Control and Network Analysis									
	MMT3E07	Dynamical System									
	MMT3E08	Measure and Integration Theory									
	MMT3O09	Equivalent MOOC Course									
Research	MMT3M10	Research Project (Minor)	--	8	8	2	50	50	100	50	4
		Total	16	12	28	--	315	235	550	275	22

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Table IV: Scheme of Teaching and Examination for Fourth Semester M.Sc. Mathematics Program Session 2023-24 onwards

Course Category	Code	Title of Course	Teaching			Examination Scheme					
							Maximum Marks				
			Theory	Practical/Project	Total	Duration (hrs.)	End Semester Examination (ESE)	Continuous Internal Assessment (CIA)	Maximum Total Marks	Minimum Passing Marks	Credits
Mandatory	MMT4T01	Differential Geometry	4	--	4	3	60	40	100	50	4
	MMT4T02	Use of Integral Transforms	4	--	4	3	60	40	100	50	4
	MMT4T03	MATLAB Programming	2	--	2	3	30	20	50	25	2
	MMT4L03	Practical 6: MATLAB Programming	--	4	4	2	25	25	50	25	2
Elective 4	**Select any one**										
	MMT4E04	Industrial Processes	4	--	4	3	60	40	100	50	4
	MMT4E05	Operation Research									
	MMT4E06	Cryptography									
	MMT4E07	Number Theory									
	MMT4O08	Equivalent MOOC Course									
Research	MMT4P09	Research Project (Major)	--	12	12	3	75	75	150	75	6
		Total	14	16	30	--	310	240	550	275	22

MMT1T01: ALGEBRA

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Understand basic terminologies and technical terms of group and ring theory.
CO2. Interpret the algebraic properties in number systems.
CO3. Apply the properties of integral domains to solve various problems.
CO4. To simplify algebraic expressions, using the commutative, associative and Distributive properties.
CO5. Differentiate between principal ideal domain, unique factorization domain, and Euclidean domain.

Unit I:
Permutation Group, Normal subgroups, Quotient groups, Dihedral group, Commutator group, Isomorphism Theorems, Automorphisms, Characteristic subgroup, Normal Series, Solvable group, Nilpotent group.

Unit II:
Cyclic decomposition of a permutation group, Alternating groups, Simplicity of A_n, Finitely generated abelian groups, Invariants of a finite abelian group, Sylow theorems, Groups of order p^2 and pq.

Unit III:
Definition and examples of Rings, Elementary properties of Rings, Types of Rings, Subrings and characteristic of a Ring, Ideals and Homomorphisms, Sum and direct sum of ideals, Maximal and prime ideals, Nilpotent and Nil ideals.

Unit IV:
Unique factorization domain, Principal Ideal domain, Euclidean domain, Polynomial rings over unique factorization domain.

Recommended Book:
Bhattacharya, Jain, and Nagpal, Basic Abstract Algebra, Second Edition, Cambridge University Press.

Reference Books:
1. Topics in Algebra, I. N. Herstein, Second Edition, John Wiley.
2. Abstract Algebra: David S. Dummit and Richard M. Foote, John Wiley
3. Michael Artin, Algebra, Prentice-Hall India.

MMT1T02: TOPOLOGY

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Demonstrate the knowledge of topological spaces and understanding of concepts such as open and closed sets, interior, closure and boundary.*
- *CO2. Use continuous functions and homeomorphisms to understand structure of topological spaces. Also create new topological spaces by using product and metric topologies.*
- *CO3. Understand the role of connected spaces, compact spaces and using these concepts classify the different compactness and connectedness of topological spaces.*
- *CO4. Express T_0, T_1, T_2, regular and normal spaces and use them to prove various properties. Also, define and categorize the countability and separation axioms.*

Unit I:
Countable and uncountable sets, Topological spaces and examples, Open sets and limit points, Derived sets, Closed sets and Closure operators, Interior, Exterior, and Boundary operators, Neighbourhoods, Bases.

Unit II:
Continuous functions and homeomorphisms, The product topology and relative topologies, The metric topology, The metrizable space.

Unit III:
Connected sets, Connected subspaces of the real line, Components and local connectedness, Compact and countably compact spaces, Compact subspaces of the real line, Limit point compactness, Local compactness.

Unit IV:
T_0-spaces, T_1-spaces, T_2-spaces and sequences, Countability axioms, Separation axioms, Regular and normal spaces, Urysohn lemma.

Recommended Book:

1. Foundations of General Topology: W.J. Pervin, Academic press, 1964.

Reference Books:

1. J.R. Munkres, Topology (second edition), Prentice-Hall of India, 2002.
2. G.F. Simmons, Introduction to Topology and Modern Analysis, Mc Graw Hill 1963.
3. J.L. Kelley, General Topology, Van Nostrand, 1995.
4. K.D. Joshi, Introduction to general Topology, Wiley Eastern Ltd. 1983

MMT1T03: ORDINARY DIFFERENTIAL EQUATIONS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Review the topic of ordinary linear differential equations with constant coefficients and develop the theory of ordinary differential equations with variable coefficients.*
- *CO2. Treat the second-order equations with regular singular points such as the Bessel equation.*
- *CO3. Investigate the existence and uniqueness of solutions of ODE with the help of successive approximation methods.*
- *CO4. Construct the systems of equations in the form of vector equations to obtain vector-valued functions.*
- *CO5. Understand the linear independency of solutions of ODE to construct general solutions.*

Unit I: Linear Equations with variable coefficients
Initial value problems for the homogeneous equations, Solutions of the homogeneous equations, The Wronskian and linear independence, Reduction of the order of a homogeneous equation, The non-homogenous equations, Homogeneous equations with analytic coefficients, The Legendre equations.

Unit - II: Linear Equations with regular singular points
The Euler equations, Second order equations with regular singular points, The Bessel equation, Regular singular points at infinity.

Unit III: Existence and uniqueness of solutions to first-order equations
The method of successive approximations, The Lipschitz condition of the successive approximation, Convergence of the successive approximation, Non-local existence of solutions, Approximations to solutions and uniqueness of solutions.

Unit IV: Existence and Uniqueness of Solutions to System of first-order equations
Central forces and planetary motion, Some special equations, Systems as vector equations, Existence and uniqueness of solutions of systems, Existence and uniqueness of linear systems.

Recommended Book:

1. E.A. Coddington, An introduction to ordinary differential equations, Prentice-Hall of India Pvt. Ltd. New Delhi (2012)

Reference Books:

1. G.F. Simmons Differential Equations with Applications and Historical note, McGraw Hill, Inc. New York. (1972)
2. G. Birkoff and G.G. Rota, Ordinary Differential equations, John Willey and Sons.
3. E.A. Coddington and N. Levinson, Theory of ordinary differential equations, Tata McGraw Hill, India.

MMT1L04: PRACTICAL 1
C-PROGRAMMING

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Understand the basic concept of C language and to apply the basic elements like Selection Statements, Switch to construct basic programs of C.
CO2. To apply the basic elements like Iteration Statements, Jump Statements and construct basic programs of C. Also compare the code of library functions and user defined functions.
CO3. To use concepts of array for Sorting, searching and Matrix Operations in C.

Topics:
Introduction to programming, programming languages, algorithm, flowcharts, C Language: Features of C, Data types, Identifiers, Constants, Variables, Operators and Expressions, Console I/O statement, Selection statements: if-else, switch. Iteration Statements: for, while, do-while, Jump statements: return, goto, break, and continue, comments, and programs using these features, Function and Recursion. Concept of Array, Matrix operations in C, Searching techniques: Linear search, Binary search. Sorting Techniques: Selection sort, Bubble sort, Insertion sort.

Practical list:
1. Write a simple program in C for Addition, multiplication and division of two numbers.
2. Write a program in C to find whether given year is Leap year or not.
3. Write a program in C for Fibonacci sequence using function.
4. Write a program in C for Factorial Function.
5. Write a program in C to demonstrate the use of Selection Statement (If, Else, Switch).
6. Write a program in C to demonstrate the use of Iterative Statement (For While Do While.).
7. Write a program in C for Transpose of matrix.
8. Write a program in C for Matrix Addition, Multiplication and Transpose.

Reference Books:
1. The C Programming Language: Dennis Ritchie & Brain Kernighan [Pearson].
2. ANSI C: E Balagurusamy (McGraw Hill Co.)
3. Higher Engineering Mathematics: B.S. Grewal (Khanna Publication)

MMT1E05: MATHEMATICAL STATISTICS

Course Learning Outcomes

On successful completion of this course, students will get the knowledge of statistics and will be able to

- *CO1. Understand the types of data and methods of its collection, and presentation of data using tables with one or more factors of classification.*
- *CO2. Present and compare the data using suitable graphs and do the analysis of quantitative data.*
- *CO3. Understand the concept of a random experiment, sample space and events, concept of probability, conditional probability, and independence of two or more events and examine them.*
- *CO4. Remember the Random variable, types of a random variable, apply and evaluate their probability distributions and some standard distributions.*
- *CO5. Formulate the applications of the random variables for real-life situations.*

Unit I:
Concept of Statistical Population and sample from a Population, Types of data: Qualitative and quantitative data, nominal and ordinal data, discrete and Continuous data, Collection and scrutiny of data: Primary data, Secondary data, its major sources, Methods of collecting data.

Unit II:
Presentation of data: Construction of tables with one or more factors of classification, Diagrammatic and graphical representation of data, Frequency distribution: Cumulative frequency distribution, Graphical representation, Histogram, frequency Polygon and Ogives, Box plot, Analysis of quantitative data: Univariate data concepts of central tendency or location, dispersion, Skewness, Kurtosis and their measures.

Unit III:
Random experiment, trial, sample point, sample space, Events, operation of events, Mutually exclusive and exhaustive events, Definition of Probability, classical and axiomatic approach to probability, Conditional Probability, Independence of events, mutual and pairwise independence, Law of addition and multiplication. Bayes theorem and its application.

Unit IV:
Definition of discrete random variables, Probability mass function, Idea of continuous random variables, Probability density function. Examples of random variables, Expectation of random variables, Standard Univariate distributions: Binomial, Negative Binomial, Poisson, Geometric, Uniform, Normal, exponential and their Properties.

Recommended Books:
1. Rohatgi V.K, An introduction to probability theory and mathematical statistics
2. Gupta S. P. : Statistical Methods.
3. Johnson S and Kotz: Distribution in Statistics, Vol I and II.

Reference Books:
1. Bhat B. R. Sriventyaramana T, Rao Mahadava K. S., Statistics: A beginners Text Vol I, Vol II, New Age International (P) Ltd. 1996
2. Goon A M, Gupta M. K. Das Gupta A.B., fundamentals of Statistics Vol I, 1999
3. Croxton F.E., Cowden D.J. and Ketins, Applied general Statistics, 1973.
4. B.L. Agrawal: Basic Statistics

MMT1E06: FUZZY MATHEMATICS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Interpret problems involving uncertainty and its quantification.
CO2. Understand fuzzy numbers and fuzzy arithmetic.
CO3. Implement fuzzy logic in various problems involving uncertainty.
CO4. Understand fuzzy systems and fuzzy control.

Unit I:
Uncertainty, Imprecision and Vagueness, Fuzzy systems, Fuzzy Sets, Fuzzy Vs crisp set, Types of fuzzy sets, Operations on fuzzy sets, Extension principle of fuzzy sets.

Unit II:
Fuzzy numbers and arithmetic, Fuzzy equations, Lattice of fuzzy numbers, Fuzzy relations and fuzzy graphs, Fuzzy morphisms.

Unit III:
Fuzzy logic, Fuzzy connectives, Fuzzy inference, Fuzzy propositions, Fuzzy quantifiers, Inference from conditional fuzzy propositions.

Unit IV:
Fuzzy systems and fuzzy control, Fuzzy rule based system, Fuzzification and Defuzzification, Design of fuzzy controllers, Examples of fuzzy systems.

Text Book:
1. Mathematics of Fuzzy Sets and Fuzzy Logic. Barnabas Bede, Springer.
2. Fuzzy Sets and Fuzzy Logic, theory and applications. George J. Klir and Bo Yuan, Prentice Hall India.

Reference Book:
1. Timothy J. Ross, Fuzzy Logic with Engineering Applications (Third Edition), Wiley, 2010.
2. Henri Prade, Fuzzy Sets and Systems Theory and Applications: Didier Dubois, Academic Press,1980.

MMT1E07: APPLIED COMBINATORICS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Understand the fundamental concepts: permutations, combinations, arrangements, and selections with repetitions.*
- *CO2. Evaluate generating function models by using different methods.*
- *CO3. Solve the Recurrence Relations models and discuss the generating function.*
- *CO4. Solve Counting problems with Venn Diagrams .understand the concept of inclusion and exclusion formula and discuss the restricted positions.*

Unit I: Basic Counting Principles
Two Basic Counting Principles, Simple Arrangements and Selections, Arrangements and Selections with Repetitions, Distributions, Binomial Identities.

Unit II: Generating Functions
Generating Functions Models, Calculating Coefficients of Generating Functions. Partitions, Exponential Generating Functions, A Summation Method.

Unit III: Recurrence Relations
Recurrence Relations Models, Divide-and-Conquer Relations, Solutions of Linear Recurrence Relations, Solutions of Non-Homogeneous Recurrence Relations, Solutions of Generating Functions

Unit IV: Inclusion-Exclusion
Counting with Venn Diagrams, Inclusion-Exclusion Formula, Restricted Positions and Rook Polynomials.

Recommended Book:
1. Alan Tucker: Applied Combinatorics 6th Edn; Wiley India.
Sections 5.1 to 5.5; 6.1 to 6.4; 7.1, 7.3; 8.1 to 8.2.

Reference Book:
1. B. Kolman, R. Busby, S.C. Ross: Discrete Mathematical Structures, 6th Edn, Pearson Edn.
2. Richer A. Brualdi, Introductory Combinatorics, Pearson.

MMT1E08: INTEGRAL EQUATIONS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Classify the integral equations and convert the ordinary differential equation into integral equation.
CO2. Understand the Degenerate, Hermitian and Symmetric kernels.
CO3. Evaluate the solutions of integral equations with Green's function type kernels.
CO4. Differentiate between linear Volterra equation and non-linear Volterra equation.
CO5. Execute approximate methods of solutions for linear integral equations.

Unit I:
Preliminary concepts of integral equations, Some problems which give rise to integral equations, Conversion of ordinary differential equations into integral equations, Classification of linear integral equations, Integro-differential equations.

Unit II:
Fredholm equations, Degenerate kernels, Hermitian and symmetric kernels, The Hilbert-Schmidt theorem, Hermitization and symmetrization of kernels, Solutions of integral equations with Green's function type kernels.

Unit III:
Types of Voltera equations, Resolvent kernel of Voltera equations, Convolution type kernels, Some miscellaneous types of Voltera equations, Non-linear Volterra equations, Fourier integral equations, Laplace integral equations.

Unit IV
Hilbert transforms, Finite Hilbert transforms, Miscellaneous integral transforms. , Approximate methods of solutions for linear integral equations, Approximate evaluation of Eigenvalues and Eigenfunctions.

Recommended Book:

1. L.G. Chambers, Integral Equations, A short course, International textbook company Ltd, (1976).

Reference Books:

1. R.P. Kanwal, Linear Integral Equation, Theory and Techniques, Academic Press, N.Y. (1971)
2. S.G. Mikhlin, Linear Integral Equations, Hindustan Book Agency, (1960)
3. A.M. Viazwaz, A First Course in Integral Equations, World Scientific (1997)
4. Larry Andrews, Bhimsen Shiramoggo, Integral Transform for Engineers, Prentice Hall of India (2003)
5. M.D. Raisinghania, Integral equations and boundary value problems by, S. Chand publication.

MMT1T10: RESEARCH METHODOLOGY IN MATHEMATICS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Recall and describe the fundamental concepts and principles of mathematics. Understand the research approaches and their significance in various fields and the different types of research designs and their characteristics.*
- *CO2. Apply research methods and approaches to investigate mathematical phenomena.*
- *CO3. Analyze the effectiveness and clarity of scientific communication and presentations.*
- *CO4. Describe the roles and dynamics within a group process, including teamwork and collaboration.*
- *CO5. Explain the concept of sponsored research and its implications for research ethics.*
- *CO6. Explain the basic principles of intellectual property rights (IPR) and their relevance in research.*

Unit I:
Introduction, Philosophy of Mathematics, Pure Mathematics, Applied Mathematics, The current state and Prospects of Geometry and Nonlinear differential equations, Meaning, objective and motivation in research, Types of research, Research approaches and significance, Research process, criteria of good research, Challenges for research in India, Defining research problem.

Unit II:
Research design, Hypothesis: Formation – Techniques – Testing, Methods of theoretical research, Scientific communication, Presentations.

Unit III:
Problem and project based learning, the group process, The project work process, Structure of Project report

Unit IV
LaTeX: Installation of the software LaTeX, Understanding Latex compilation, Page Layout, List making environments, Applications for writing resumes, question papers, articles/research papers, Presentations using Beamer.
Sponsored research, Ethics of research, intellectual property rights (IPR).

Reference Books:
1. Rama Nand Singh, Research Methodology and Techniques in Mathematics, Centrum Press, New Delhi, India.
2. C.R. Kothari, Research Methodology, New Age International (P)Ltd., India.
3. John Kuda, Research Methodology: A Project Guide for University Students, Samfunds Litterature.

MMT1L10: RESEARCH METHODOLOGY IN MATHEMATICS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Understand the mechanism of the research project.
CO2. Study and explain a research project.
CO3. Prepare a review report of the project.
CO4. Analyze the structure and components of a project report to ensure coherence and clarity.

Practical List:

Study of Research Project Reports on

1. Student's Ability to Relate the Definition of a Function to its Representations.
2. Unique Prime Factorization of Ideals in the Ring of Algebraic Integers of an Imaginary Quadratic Number Field
3. Simple Groups and Related Topics
4. Symmetric Presentations of Non-Abelian Simple Groups
5. Hilbert Spaces and Fourier Series
6. Homomorphic Images and Related Topics
7. Geometric Constructions From an Algebraic Perspective
8. An Introduction to Boolean Algebras
9. Bio-Mathematics: Introduction to the Mathematical Model of the Hepatitis C Virus
10. Construction of Finite Group
11. Simple and Semi-Simple Artinian Rings
12. Construction of Homomorphic Images
13. Non-Abelian Finite Simple Groups as Homomorphic Images
14. Symmetric Presentation of Finite Groups, and Related Topics
15. Measure and Integration
16. The Complexity of Linear Algebra
17. Coding Theory
18. Matroid Theory
19. Study on Energy of Graph
20. Digital Topology
21. Study on Semigraphs
22. Queuing Theory
23. Concepts and Results on Fuzzy Metric Space
24. Introduction to Topological Manifold
25. Bilinear Forms
26. Semigroups
27. Fixed Point Theorems in Topology and Geometry
28. Stationary Solutions of Navier Stokes Equations
29. A Collection of Fast Algorithms for Scalar and Vector-Valued Data on Irregular Domains: Spherical Harmonic Analysis, Divergence-Free/Curl-Free Radial Basis Functions, and Implicit Surface Reconstruction
30. Numerical Computing with Functions on the Sphere and Disk
31. Stability and Convergence for Nonlinear Partial Differential Equations
32. Analytic Solutions for Diffusion on Path Graphs and its Application to the Modeling of the Evolution of Electrically
33. Analytical Upstream Collocation Solution of a Quadratic Forced Steady-State Convection-Diffusion Equation
34. Radial Basis Function Finite Difference Approximations of the Laplace-Beltrami Operator

35. Solution Techniques and Error Analysis of General Classes of Partial Differential Equations
36. Nonlinear Partial Differential Equations, their Solutions, and Properties
37. A Radial Basis Function Partition of Unity Method for Transport on the Sphere
38. The Impact of a Quantitative Reasoning Instructional Approach to Linear Equations in Two Variables on Student Achievement and Student Thinking About Linearity
39. Student Understanding of Function and Success in Calculus
40. Latin Squares and their Applications to Cryptography
41. On the Fundamental Group of Plane Curve Complements
42. Regular Homotopy of Closed Curves on Surfaces
43. The Grasshopper Problem
44. The Classification of Countable Models of Set Theory
45. Computable Reducibility of Equivalence Relations

Reference Links:

https://scholarworks.lib.csusb.edu/mathematics-etd/

http://dspace.christcollegeijk.edu.in:8080/jspui/handle/123456789/1334

https://scholarworks.boisestate.edu/do/discipline_browser/disciplines?discipline_key=114

MMT2T01: REAL ANALYSIS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Describe the basic differences between the sequence of functions and the series of functions.
CO2. Give the essence of the proof of the Stone-Weierstrass theorem, the contraction principle as well as the inverse function theorem.
CO3. Understand and perform simple proofs.
CO4. Give the definition of concepts related to metric spaces, topological manifolds, differential manifolds, and real projective space.
CO5. Answer questions concerning the rank of mapping, immersion, and some examples of lie groups.

Unit I:
Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Equicontinuous families of functions, The Stone-Weierstrass theorem.

Unit II:
Differentiation, The Contraction Principle, The Inverse Function Theorem, The Implicit Function Theorem, The Rank Theorem, Partitions of Unity.

Unit III:
The space of tangent vectors at a point of R^n, Another definition of Ta (R^n), Vector fields on open subsets of R^n, Topological manifolds, Differentiable manifolds, Real Projective space, Grassman manifolds, Differentiable functions and mappings.

Unit IV:
The rank of a mapping, Immersion, Sub-manifolds, Lie groups, Examples of Lie groups, The action of a lie group on a manifold, Transformation groups, The action of a discrete group on a manifold, Covering manifold.

Recommended Books:
1. Walter Rudin, Principles of Mathematical Analysis (Third Edition), Mc GRAW-HILL Book Company.
2. W. Boothby, An Introduction to Differentiable Manifolds and Riemannian Geometry, Academic Press, 1975.

Reference Books:
1. R. R. Goldberg, Methods of Real Analysis, John Wiley.
2. C Goffman, Calculus of Several Variables, Harper and Row.

MMT2T02: FLUID DYNAMICS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Describe the physical properties of a fluid, motion of fluids and the principles of motion for fluids.*
- *CO2. Identify how to derive basic equations of motion and know the related theories.*
- *CO3. Calculate the pressure distribution for incompressible fluids and calculate the complex potentials for two-dimensional flow.*
- *CO4. Formulate the equation of motion of gas.*
- *CO5. Demonstrate the reservoir discharge through a channel varying section.*
- *CO6. Make dimensional analysis and similitude.*
- *CO7. Use the dimensional analysis, derive the dimensionless numbers and set up the relation between a model and prototype.*

Unit I:
Real fluids and ideal fluids, Velocity of a fluid at a point, Streamlines and path lines, Steady and unsteady flows, Velocity potential, Vorticity vector, Local and particle rate of change, Equation of continuity, Acceleration of a fluid, Conditions at a rigid boundary, General analysis of fluid motion, Euler's equation of motion, Bernoulli's equation, Worked examples, Discussion of the case of steady motion under conservative body forces, Some further aspects of vortex motion.

Unit II:
Sources, sinks and doublets, Images in a rigid infinite plane and solid spheres, Axisymmetric flows, Stoke's stream function, The complex potential for two-dimensional, irrotational, incompressible flow, Complex velocity potential for standard two-dimensional flow, Uniform stream, Line source and line sink, Line doublets, Line vortices, Two-dimensional image systems, The Milne-Thomson circle theorem, Some applications of the circle theorem, Extension of circle theorem, The theorem of Blasius.

Unit III:
The equation of state of a substance, the first law of thermodynamics, Internal energy of a gas, functions of state, entropy, Maxwell's thermodynamic relations, Isothermal, Adiabatic and Isentropic processes, Compressibility effects in real fluids, The elements of wave motion, One-dimensional wave equation, Wave equation in two and three dimensions, Spherical waves, Progressive and stationary waves.

Unit IV:
The speed of sound in a gas, Equations of motion of a gas, Sonic, subsonic, supersonic flows, Isentropic gas flow, Reservoir discharge through a channel of varying section, investigation of maximum mass flow through a nozzle, Shock waves, Formation of shock waves, Elementary analysis of normal shock waves, Navier-Stokes equations of motion of a viscous fluid, Dynamical similarity, Buckingham theorem, Boundary layer equations and boundary layer thickness.

Recommended Book:
1. F. Chorlton, Text book of Fluid Dynamics, CBS Publishers, Delhi 1985.

Reference books:
1. G.K. Batchelor, An Introduction to fluid Mechanics, Foundation Books, New Delhi 1994.
2. M.D. Raisinghania, fluid Mechanics, S. Chand and Company, Delhi.
3. H. Schichting, Boundary layer theory, Mc Graw Hill Book Company, New York 1971

MMT2T03: PARTIAL DIFFERENTIAL EQUATIONS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Understand the basic properties of standard PDEs.*
- *CO2. Demonstrate capacity to model physical phenomena using PDEs (in particular using the heat and wave equations).*
- *CO3. Apply problem-solving using concepts and techniques from PDEs applied to diverse situations in physics, and engineering contexts.*
- *CO4. Classify PDEs, apply analytical methods, and physically interpret the solutions.*
- *CO5. Understand what are well-posed initial (and/or boundary) value problems for classical PDEs such as the wave equation, the Laplace equation, and the heat (diffusion) equation*
- *CO6. Identify the type of nonlinear PDE and apply the Charpit method to find solution.*
- *CO7. Apply Duhamel's principle to solve wave and heat equations.*

Unit I:
Curves and surfaces, Classification of the first order PDE, Classification of integrals, Linear equations of the first order PDE, Quasilinear equations: Geometry of solutions, Integral surfaces passing through a given curve, Surfaces orthogonal to a given system of surfaces.

Unit II:
Nonlinear partial differential equations of the first order, Cauchy's method of Characteristics, Compatible systems of first-order equations, Charpit's method, Solutions satisfying given conditions, Classification of the second order PDE, Nonlinear equations of the second order.

Unit III: Laplace's Equation
Families of equipotential surfaces, Boundary value problems, Maximum and minimum principles, The Cauchy problem, The Dirichlet problem and the Neumann problem for the upper half plane, The Dirichlet problem and the Neumann problem for a circle, The Dirichlet exterior problem for a circle, The Dirichlet problem for a rectangle, Harnack's theorem, Laplace's equation-Green's function, the Dirichlet problem for a half plane and a circle.

Unit IV: The Wave and Diffusion Equations
The occurrence of the wave equation in physics, Vibrations of an infinite, semi-infinite and finite string, Riemann's method, Vibrations of a string of finite length (Separation of variables), The occurrence of the diffusion equation in physics, Finite and infinite rod case of heat conduction, Duhamel's principle for wave and heat conduction equations.

Recommended Books:
1. I N. Sneddon, Elements of Partial Differential Equations, Tata Mc Graw Hill Int.
2. T. Amarnath, An Elementary Course in Partial Differential Equations, 2nd Ed., Narosa Publishing House

Reference Book:
1. I.P. Stavroulakis and S.A. Tersian, Partial Differential Equations (Second Edition), World Scientific Publishing Co. Re. Ltd.
2. G.B. Polland, Introduction to Partial Differential Equations, Overseas Press, 1995.

MMT2L04: PRACTICAL 3 (R-PROGRAMMING)

Course Learning Outcomes

On successful completion of this course, students will be able to

CO1. Understanding the R programming language, including installing R and RStudio, utilizing R's documentation system, performing calculations, data manipulation and working with matrices.

CO2. Utilizing conditional executions, loops, sequence generation, sorting techniques, data frame creation and manipulation, vector indexing, and various operations on data frames in R, enabling them to effectively analyze and manipulate data for diverse applications.

CO3. Organize a display and format data using print and format functions, concatenate strings, conduct search operations on strings and other data, and manipulate factors through examples and operations in R.

CO4. Create various graphics and plots, including boxplots, bivariate plots, and three-dimensional plots, to analyze data and visually represent measures of central tendency, variation, skewness, and kurtosis.

Topics:

Why R, Installation Procedure and How to Start, Command line, Libraries, Packages and Data Editor, Introduction to R Studio, Basics of Calculations and R as a Calculator with Data Vectors, Built-in Functions, Assignments, Introduction to Matrix, Matrix Operations, Missing Data and Logical Operators, Truth Table, Conditional Executions & Loops, Repeat Loops and Sequences of Numbers, Dates and Alphabets, Repeats, Sorting and Mode, Ordering and Lists, Vector Indexing, Data Frames: Creation and Operations, Display using Print & Format Functions with Concatenate and Paste Function & Splitting, Substitution in Strings, Search in Strings and Other Data Operations, Factors-Examples and Operations, Importing, Reading and Saving Data Files, Frequencies, Partition Values, Graphics, Plots and Central Tendency of Data, Variation in Data, Boxplots, Skewness, Kurtosis, Bivariate and Three Dimensional Plots.

Practical list:

1. Find sum, mean and product of a vector.
2. Calculate arithmetic operation and array.
3. Solve basic matrices operation and element-by-element matrix operation.
4. Find determinant of matrix, Inverse of matrix, Find Eigen value, Eigen Vector, Rank of Matrix.
5. Count the number of vector values in range and count the specific value.
6. Create a sequence of numbers, alphabets, date, strings.
7. Create some repetitive commands by using conditional statements.
8. Create a list and sort, also count number of elements in the list.
9. Create a data frame, combine & merge data frames.
10. Formatting & display of strings by using print, format, cat & paste functions.
11. Determine different functions of factor.
12. How to import, read and save the data files.
13. Calculate Absolute Frequency, Relative Frequency, and Frequency Distribution.
14. Find Arithmetic Mean, Median, Mode, Geometric Mean, and Harmonic Mean.
15. Calculate Quantiles, Range, Interquartile Range and Quartile Deviation.
16. Calculate central tendency, variation, Skewness, and kurtosis.

Recommended Books:

1. Prof. Shalabh, Introduction to R Software, Mathematics, IIT Kanpur.
2. Prof. Shalabh, Descriptive Statistics with R Software, Mathematics, IIT Kanpur.

MMT2E05: DESIGN OF EXPERIMENTS

Course Learning Outcomes

On successful completion of this course students will get the knowledge about how to design an experiment for comparing various effects on the output of an experiment through following designs and will be able to

CO1. Understand basic designs like CRD, RBD, LSD, their analysis, and the techniques of estimating missing values in the data.
CO2. Use of BIBD and its various types such as RBIBD, ARBIBD, SBIBD, and Youden square design.
CO3. They learn the use of factorial experiments according to the situation where the effects of treatments are studied at two levels and their interactions and will be able to decide which design is better to apply.
CO4. Use of confounding in factorial experiments to maintain homogeneity of the block. Understand and use the concept of double confounding.
CO5. At the end of this course, students will be able to design and model the experiment according to the conditions of the data set.

Unit I:
Basic principles of experimental design , Analysis of variance, one way and two-way classified data, Randomization structure and analysis of completely randomized design (CRD), randomized, block design (RBD) and Latin square design (LSD), Missing plot technique in RBD and LSD with one and two missing values (only estimation).

Unit II:
Incomplete block designs, balanced incomplete block design (BIBD), Parametric relations and analysis of BIBD, Connectedness and orthogonality, BIBD with recovery of inter-block information PBIBD with two associate classes, Definitions and parametric relations of SBIBD, RBIBD, ARBIBD, PBIBD, Youden Square Design-definition and analysis.

Unit III:
Factorial experiments, Factorial effects, best estimates and testing the significance of factorial effects, Analysis of 2^n (2^3 and 2^4) factorial experiments in randomized blocks. Split plot designs-construction and analysis, Analysis of covariance for one way and two way classified data.

Unit IV:
Confounding and fractional replication in factorial experiments, complete and partial confounding, Simultaneous confounding, double confounding, Concept of generalized interaction, Design for study of response surfaces.

Recommended Books:
1. Das M.N. and Giri N., Design and Analysis of experiments, Wiley Eastern (1997)
2. Alok Dey Theory of Block design. Wiley Eastern

Reference Book:
Montgomery C.D. Design and Analysis of experiments. Wiley, New York (1976).

MMT2E06: LINEAR PROGRAMMING

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Demonstrate understanding of fundamental properties, apply the simplex method and dual simplex method, solve simultaneous linear equations, and formulate dual problems in linear programming.*
- *CO2. Apply advanced techniques in linear programming, including the revised simplex method, handling bounded variables, parametric and linear fractional programming, and understanding the Karmarkar algorithm.*
- *CO3. Analyze and apply post-optimal analysis techniques to assess the impact of structural changes in objective function coefficients & variable values on LP solutions, including the exploration of real-world applications.*
- *CO4. Categorize and formulate linear goal programming problems and understand Gomory's cutting plane algorithm and branch & bound method for solving integer programming problems.*

Unit I: Simplex Method

Fundamental properties of solutions, The computational procedure, Use of Artificial variables, Degeneracy in linear programming, Solution of simultaneous linear equation, Inverting a matrix using simplex method, Applications of simplex method, General primal-dual pair**,** Formulating a dual problem**,** Primal-dual pair in matrix form**,** Dual simplex method.

Unit II: Linear Programming Problem–Advanced Techniques

Revised simplex method, Bounded Variable, Parametric Linear Programming, Linear Fractional Programming, Karmarkar Algorithm.

Unit III: Post-optimal analysis

Changes in objective function coefficients c_j's, Changes in the b_i values, Changes in the coefficients a_{ij}'s, Structural changes, Applications of post-optimal analysis.

Unit IV: Goal and Integer Programming

Goal Programming: Categorisation of goal programming, Formulation of linear goal programming problem, Graphical goal attainment method, Simplex method for goal programming problem.

Integer Programming: Gomory's cutting plane algorithm, Branch and bound method.

Recommended book:

1. Kanti Swarup, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand and Sons New Delhi.

Reference Books:

1. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
2. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997
3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001

MMT2E07: ADVANCED DISCRETE MATHEMATICS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Understand mathematical modeling of discrete structures.
CO2. Apply discrete mathematics to solve puzzles.
CO3. Solve recurrence relations using generating function.
CO4. Understand mathematical terminology related to language and grammar.
CO5. Interpret deterministic and non-deterministic automata.

UNIT I:
Matrix representation of graphs- Incidence matrix, Cut set matrix, Path Matrix, Circuit Matrix and Adjacency matrix, Directed graphs, types of directed graphs, Binary search trees.

UNIT II:
Discrete Numeric functions, Asymptotic Behavior of Numeric functions, Generating functions, Recurrence Relations- Linear Recurrence Relations with constant coefficients, Homogeneous solutions, particulars solutions, Total Solutions.

UNIT III:
Computability and Formal languages- Languages, Phrase structure grammars, Derivation, Sentential forms, Language generated by grammar, Regular, context-free and context sensitive grammar

UNIT IV:
Finite State Automata, Diagram & Language determined by an Automaton, Finite State Acceptors, Deterministic and Non-deterministic Finite Automata, Finite State Machines, their transition tables & diagrams, Equivalent machines.

Recommended Book:
1. J.P. Tremblay & R. Manohar, Discrete Mathematical Structures, McGraw Hill.
2. N. Deo, Graph theory with applications, Prentice Hall.

Reference Book:
1. C.L. Liu, Elements of Discrete Mathematics McGraw Hill.
2. Semyour Lipschutz and Marc Lipson, Discrete Mathematics, McGraw Hill.

MMT2E08: LINEAR ALGEBRA AND DIFFERENTIAL EQUATIONS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Recognize the concepts of the terms span, linear independence, basis, dimension, and apply these concepts to various real vector spaces and subspaces. In addition, to find the solution of linear differential equations with real distinct Eigen values.*
- *CO2. Apply the concepts of complex linear algebra to distinct vector spaces and subspaces to find the solution of differential equations.*
- *CO3. Understand the concept of topology in R^n and explore the concept of norms and exponential operators, while also developing skills in solving homogenous and non-homogeneous linear systems as well as higher-order systems.*
- *CO4. Understand the concept of primary decomposition, S+N decomposition and apply these concepts to solve differential equations, which include different forms such as nilpotent, Jordan and real canonical form.*

Unit I: Linear System with Constant Coefficient and Real Eigenvalues
Basic Linear Algebra, Real Eigen Values, Differential equations with Real Distinct Eigenvalues.

Unit - II: Linear System with Constant Coefficient and Complex Eigenvalues
Complex Eigen values, Complex vector spaces, Real operators with Complex Eigenvalues, Application of complex linear algebra to differential equations.

Unit III: Linear System and Exponentials of Operators
Review of topology in R^n, New norms for old, Exponential of operators, Homogeneous linear systems, A non-homogeneous equation, Higher order systems.

Unit IV: Linear System and Canonical Forms of Operators
The primary decomposition, The S+N decomposition, Nilpotent canonical forms, Jordan and real canonical forms, Canonical forms and differential equations, Higher order linear equations, Operators on function spaces.

Recommended Book:
M.W. Hirsch and S. Smale, Differential Equations, Dynamical Systems and Linear Algebra, Academic Press, 1975.

Reference Book:
V.I. Arnold, Dynamical systems, Springer Verlag, 1992.

MMT3T01: COMPLEX ANALYSIS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Represent complex numbers algebraically and geometrically.*
- *CO2. Analyze limit, continuity and differentiation of functions of complex variables.*
- *CO3. Understand Cauchy-Riemann equations, analytic functions and various properties of analytic functions.*
- *CO4. Understand Cauchy theorem and Cauchy integral formulas and apply these to evaluate complex contour integrals.*
- *CO5. Represent functions as Taylor and Laurent series; classify singularities and poles; find residues and evaluate complex integrals using the residue theorem.*
- *CO6. Understand maximum principle, schwarz's lemma and convex functions.*

Unit I:
Impossibility of ordering Complex numbers, Extended complex plane and stereographic projection, Elementary properties and examples of analytic functions, Power series, Analytic functions.

Unit II:
Analytic functions as mappings, Mobius transformations, Power series representation of analytic functions, Zeros of an analytic function, Index of a closed curve.

Unit III:
Cauchy's theorem and integral formula, The homotopic version of Cauchy's theorem and simple connectivity, Counting zeros, The open mapping theorem, Goursat's theorem, Classification of singularities, Residues, The argument principle.

Unit IV:
The maximum principle, Schwarz's lemma, Convex functions and Hadamard's three circles theorem, Phragmen-Lindelof theorem.

Recommended Book:
1. John B. Conway, Functions of one complex variable: Second edition, Springer international Student Edition.

Reference Book:
1. Complex Analysis, L.V. Ahlfors. Mc-Graw Hill, 1966

MMT3T02: FUNCTIONAL ANALYSIS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Exemplify normed spaces and Banach spaces.
CO2. Interpret Hilbert spaces and functional on the Hilbert spaces.
CO3. Understand representation of functionals on Hilbert spaces.
CO4. Explain convergence of operators and functional and operators.

Unit I:
Normed spaces, Banach spaces, Further properties of normed spaces, Finite-dimensional normed spaces and subspaces, Compactness and finite dimension, Bounded and continuous linear operators.

Unit II:
Linear functionals, Normed spaces of operators, Dual spaces, Inner product space, Hilbert space, Further properties of inner product spaces, Orthogonal complements and direct sums, Orthonormal sets and sequences, Total orthonormal sets and sequences.

Unit III:
Representation of functionals on Hilbert spaces, Hilbert adjoint operators, self-adjoint, unitary and normal operators, Hahn-Banach Theorem, Hahn-Banach Theorem for complex vector spaces and normed spaces, Reflexive spaces.

Unit IV:
Category theorem, Uniform boundedness theorem, strong and weak convergence, Convergence of sequences of operators and functionals, Open mapping theorem, Closed linear operators and closed graph theorem.

Recommended Book:
1. E. Kreyszig, Introductory Functional Analysis with Applications by John Wiley and Sons.

Reference Books:
1. A.E. Taylor and D.C. Lay, Introduction to Functional Analysis by John Wiley and Sons.
2. Introduction to Topology and Modern Analysis: G.F. Simmons, McGraw Hill.

MMT3T03: ADVANCE NUMERICAL METHODS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Understand the physical and mathematical basic theory of numerical analysis.*
- *CO2. Apply the theory of numerical analysis to obtain the best approximate solutions to complex problems.*
- *CO3. Find out the approximations of functions whose values are known only at discrete points.*
- *CO4. Develop numerical integration rules and methods for the approximate solutions of differential and integral equations.*
- *CO5. Develop the Romberg integration to increase the degree of accuracy to solve integrations.*
- *CO6. Compare the methods of solutions of the ordinary differential equations on the basis of accuracy.*
- *CO7. Analyze convergence and errors in computational methods of solutions of initial value problems.*

Unit I: **Interpolation**
Polynomial interpolation, Trigonometric interpolation, Spline interpolation, Bezier polynomials.

Unit II: Numerical Integration
Interpolatory quadrature, Convergence of quadrature formulae, Gaussian quadrature formulae, Quadrature of periodic functions, Romberg integration, Improper integrals.

Unit III: **Initial Value Problem**
The Picard-Lindelof theorem, Euler's method, Single-step methods, Multistep methods.

Unit IV: **Boundary Value Problems**
Shooting method, Finite difference methods, The Riesz and Lax-Milgram theorem, Weak solutions, The finite element method.

Recommended Book:

2. Rainer Kress, Numerical Analysis Springer (India) Pvt. Ltd. (2014).

Reference Books:

1. S.S. Sastry, Introductory Methods of Numerical Analysis, 5th Ed., PHI Learning Pvt. Ltd. (2015)
2. K.E. Atkinson, An Introduction to Numerical Analysis, 2nd Ed., Wiley India (P) Ltd. (2008)
3. J.W. Thomas, Numerical Partial Differential Equations Finite Difference Methods, Springer-Verlag New York, Inc. (1995).

MMT3L04: PRACTICAL 5 (PROGRAMMING WITH PYTHON)

Course Learning Outcomes

On successful completion of this course, students will be able to

CO1. Understand the basic concept of Python and its uses. Determine the methods to create and manipulate Python programs by utilizing the data structures like lists, dictionaries, tuples and sets. Also, apply the basic elements of Python like basic data types, decision statements, looping statements to construct basic programs of Python.

CO2. Understand the features and benefits of user defined functions in python. Also, gain the knowledge of file handling in python and use the mechanism of file handling in file attributes, command line arguments, various operating system.

CO3. Explore distinct string handling operations in python such as using loops, string operators, and string functions. Also, discuss the concept of object-oriented paradigm, distinct classes, and objects, which are used to construct the basic program in Python.

Topics:

Introduction, Features of Python: Easy, Type and Run, Syntax, Mixing, Dynamic Typing, Built in Object Types, Numerous Libraries and Tools. Chronology and Uses, Basic Data Types Revisited: Fractions, Strings, Lists and Tuples, Features of Tuples. **Conditional Statements**: if, if-else, and if-elif-else constructs. The if-elif-else Ladder. Logical Operators. The Ternary Operator. Examples. **Looping:** While, Patterns, Nesting and Applications of Loops in Lists. **Functions:** Features of functions: Modular Programming, Reusability of Code, and Manageability, Basic Terminology: Name of Functions, Arguments, Return Value, Definition and, Invocation: Working. Type of Functions: Advantage of Arguments, Recursion: Rabbit Problem; Disadvantages of Using Recursion. **Iterations, Generators, and Comprehensions:** The Power of "For". Iterators, Defining an Iterable Object, Generators, Comprehensions. **File Handling:** The File Handling Mechanism. The Open Function and File Access Modes. Python Functions for File Handling: The Essential Ones, The OS Methods, Miscellaneous Functions and File Attributes, Command Line Arguments, Implementation and Illustrations. **Strings:** The Use of "For" and "While". String Operators: The Concatenation Operator (+), The Replication Operator, The Membership Operator. Functions for String Handling: len(), Capitalize(), find(), count, Endswith(), Encode, Decode. **Introduction to Object-Oriented Paradigm:** Creating New Types, Attributes and Functions. Elements of Object-Oriented Programming: Class, Object, Encapsulation, Data Hiding; Inheritance; Polymorphism; Reusability. **Classes and Objects:** Defining a Class. Creating an Object, Scope of Data Members, Nesting.

Practical list:

1. Python program to find roots of quadratic equation.
2. Python program to add digits of a number.
3. Write a program in python to swap two numbers.
4. Python program to print given number in reverse order.
5. Write a program in python to print the Fibonacci sequence.
6. Write a program in python to find factorial of a number using recursion.
7. Write a program in python to find entered number is prime or not.
8. Write a program in python to find the sum of digits in a number using function.
9. Write a program in python for the addition of two matrix.

Reference Books:

1. Beginning-Python, Second Edition by Magnus Lie Hetland
2. The Complete Reference Python by Martin C. Brown
3. Learning Python, O"Reilly by Mark Lutz
4. Python in a Nutshell, O"Reilly by Alex Martelli

MMT3E05: NON-PARAMETRIC METHODS AND MULTIVARIATE ANALYSIS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Understand when, where and how to apply various non-parametric methods to different types of data for testing various types of hypotheses.*
- *CO2. Understand and differentiate various non-parametric tests for one sample, paired samples and two independent samples problem.*
- *CO3. Develop the ability of handling multivariate data and to draw inferences from such data using various methods.*
- *CO4. Understand and compare the concepts of multiple and partial correlation and multiple regression.*
- *CO5. Explain and implement normal distribution and its properties, Wishart distribution and its properties.*
- *CO6. Understand and classify Hotelling's T^2, problem of classification, Principal component analysis which is useful in the dimension reduction.*

Unit I:
Definition of non-parametric test, Advantages and disadvantages of Nonparametric tests, Single sample problems: Test of randomness, Test of good ness of fit: Empirical distribution function, Kolmogorov– Smirnov test, Chi-square test, Comparison of Chi square test & KS test, One sample problem of location: Sign Test, Wilcoxon's signed rank test, Wilcoxon paired sample signed rank test.

Unit II:
Two sample problems: Different types of alternatives, Sign test, Wilcoxon's two sample rank sum test, Wald-Wolfowitz run test, Mann-Whitney-Wilcoxon test, Median test, KS-two sample test, Klotz Normal score test, One sample U-statistic, Kernel and symmetric Kernel Variance of U, Statistic, two-sample U-statistic, Linear rank Statistics and their distributional properties under null hypothesis.

Unit III:
Bivariate data: Correlation coefficient and its Properties, Regression, Principle of least squares, fitting of linear regression, Rank correlation, Multiple and partial correlation, Linear and multiple regression coefficient of determination and its uses, Tests of significance of multiple and partial correlation coefficient, Multivariate normal distribution, Characteristic function, moments, marginal and conditional distribution, Inference of parameters of multivariate normal distribution.

Unit III:
Wishart distribution and its properties, Distribution of sample generalized variance, Hotelling's T square and its null distribution (only statements), Principal Components, Classification, Misclassification and its probabilities.

Recommended Books:
1. Gibbons J.D., Nonparametric Statistical inference
2. Kshirsagar A. M., Multivariate analysis

Reference Book:
Anderson T.W., An introduction to Multivariate Statistical analysis

MMT3E06: INVENTORY CONTROL AND NETWORK ANALYSIS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Analyze decision-making problems, processes, and environments. Also evaluate and interpret decision tree analysis and utility theory.*
- *CO2. Explain the concept of Economic Order Quantity and its application. Also solve deterministic inventory problems with and without shortages. Apply selective inventory control techniques and manage uncertain demand.*
- *CO3. Solve network flow problems, including minimal spanning tree, shortest route, maximal flow, and minimum cost flow problems. Analyze and optimize network structures and flows.*
- *CO4. Understand network components and sequencing in project scheduling, analyze and optimize project schedules with consideration of critical paths and time-cost trade-offs, and effectively allocate resources using relevant optimization algorithms.*

Unit I: Decision Analysis
Decision making problem, Decision making process, Decision making environment, Decision under uncertainty, Decision under risk, Decision tree analysis, Decision making with utilities.

Unit II: Inventory Control
The concept of EOQ, Deterministic inventory problems without shortages, Deterministic inventory problems with shortages, Problems of EOQ with price breaks, Multi-item deterministic problems, Dynamic order quantity, Selective inventory control techniques, Inventory problems with uncertain demand, Systems of inventory control.

Unit III: Network Routing Problems
Network flow problems, Minimal spanning tree problem, Shortest route problems, Maximal flow problems, Minimum cost flow problems, More network flow problems, Insight into big networks.

Unit IV: Network Scheduling and Resource Analysis
Network: Basic components, Logical sequencing, Rules of network construction, Concurrent activities, Critical path analysis, Probability considerations in PERT, Distinction between PERT and CPM, Time-cost optimization algorithm, Resource allocation and scheduling, MOST and GERT.

Recommended Book:
Kanti Swarup, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand and Sons New Delhi.

Reference Books:
1. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
2. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997
3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001

MMT3E07: DYNAMICAL SYSTEMS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Recall vector fields and the fundamental theorems.
CO2. Interpret the flow of differential equation.
CO3. Exemplify nonlinear sinks, Gradient and inner product.
CO4. Apply Poincare-Bendixson theorem.
CO5. Analyze discrete dynamical systems.

Unit I: Fundamental Theory
Dynamical systems and vector fields, The fundamental theorem, Existence and Uniqueness, Continuity of solutions in initial conditions, On extending solutions, Global solutions, The flow of a differential equation.

Unit - II: Stability of Equilibria
Nonlinear sinks, Stability, Liapunov functions, Gradient systems, Gradients and Inner products.

Unit III: The Poincare-Bendixson Theorem
Limit sets, Local sections and flow boxes, Monotone sequences in planar dynamical systems, The Poincare Bendixson theorem, Applications of Poincare-Bendixson theorem, Ecology.

Unit IV: Periodic Attractors
Asymptotic stability of the closed orbit, Discrete dynamical systems, Stability and closed orbits, Non-autonomous equations and differentiability of flows, Persistence of equilibria, the persistence of closed orbits, Structural stability.

Recommended Book:
M.W. Hirsch and S. Smale, Differential Equations, Dynamical Systems and Linear Algebra, Academic Press, 1975.

Reference Book:
V.I. Arnold, Dynamical systems, Springer Verlag, 1992.

MMT3E08: MEASURE AND INTEGRATION THEORY

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. To generalize the concept of outer measure, Lebasque measure and measurable functions.*
- *CO2. Understand the essential differences between the theories of Lebesgue and Riemann integration.*
- *CO3. To develop the concept of L_p-spaces.*
- *CO4. Know the basic concepts and some central proof ideas related to Baire category, Arzela Ascoli and sigma compact spaces.*

Unit I:
Outer measure, Measurable sets and Lebesgue measure, Anon-measurable set, Measurable functions, Littlewood's three principles.

Unit II:
The Riemann integral, Lebesgue integral of a bounded function over a set of finite measures, Integral of a non-negative function, General Lebesgue integral, Convergence in measure, Differentiation of monotone functions, Functions of bounded variation, Differentiation of an integral.

Unit III:
Absolute continuity, Convex functions, L_p-spaces, Holder and Minkowski inequality, Riesz-Fischer theorem, Approximation in L_p-spaces, Bounded linear functionals on L_p-spaces.

Unit IV:
Compact metric spaces, Baire category theorem, Arzela Ascoli theorem, Locally compact spaces, Sigma compact spaces.

Recommended Book:

3. H.L. Royden, Real Analysis, Third edition, Prentice Hall, 1988.

Reference Books:

3. Andrew Browder, Mathematical Analysis, An Introduction, Springer
4. G. de Barra, Measure theory and Integration, Wiley Eastern Limited, 1981.
1. Inder K. Rana, An introduction to Measure & Integration, Narosa Publishing House

MMT4T01: DIFFERENTIAL GEOMETRY

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

- *CO1. Understand the classical theory of curves and surfaces.*
- *CO2. Develop a theory of space curves using Serret-Frenet formulae.*
- *CO3. Understand the geometric concept of the geodesic.*
- *CO4. Apply the theory of first and second fundamental forms, geodesic on surfaces, and fundamental equations of the surface theory to study geometrical surfaces.*
- *CO5. Illustrate the properties of geodesic on a surface.*
- *CO6. Classify different points on a surface and find maximum and minimum curvature along a given direction.*

Unit I: The First Fundamental form
Curves on the surface, Surface of revolution, Helicoids, Metric, Direction coefficients, Families of curves, Isometric correspondence, Intrinsic properties.

Unit II: **Geodesics on a Surface**
Canonical geodesic equations, Normal property of geodesic. Existence theorem, Geodesic parallels, Geodesic curvature, Gaussian curvature, Surfaces of constant curvature, Conformal and geodesic mappings.

Unit III: **The Second Fundamental form**
Principal curvatures, Lines of curvature, Developable associated with space curves and curves on surfaces, Minimal and ruled surfaces.

Unit IV: Fundamental Equations of Surface Theory
Gauss Equations, Weingarten equations, Mainardi-Codazzi equations, Parallel surfaces, Fundamental existence theorem for surfaces.

Recommended Book:
D. Somasundaram, Differential Geometry: A First Course, Alpha Science International Ltd., Harrow, U.K.

Reference Book:
T.J. Willmore, An Introduction to Differential Geometry, Oxford University Press, New Delhi.

MMT4T02: USE OF INTEGRAL TRANSFORMS

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Understand the concept Fourier transform and its commonly used properties. Apply these concepts to develop the functions such as simple, rational functions and discuss its applications to solve the boundary value problems like Laplace's Equation, Diffusion Equation, Vibration Problems.

CO2. Understand the Mellin transform, including its properties, calculations, applications in solving integral equations and analyzing potential distributions, and its role in mathematical summation series.

CO3. Understand and apply the Hankel transform, including its properties, inversion theorem, calculations and discuss its use in the solution of partial differential equations and its relationship with Fourier transforms.

Unit I: Fourier Transform

Fourier integral theorem, Fourier transforms, Fourier transforms of derivatives, Fourier transforms of functions, The convolution integral, Parseval's theorem for Cosine and Sine transforms, Multiple Fourier transform, Finite Fourier transform.

Unit II: Applications of Fourier Transform

The solution of integral equations of convolution type, Solution of partial differential equation by means of Fourier transforms (Laplace's Equation, Diffusion Equation, Vibration Problems).

Unit III: The Mellin Transform

Elementary properties of the Mellin transform, Mellin transforms of derivatives and integrals, The Mellin inversion theorem, Convolution theorems for the Mellin transform, The solution of some integral equations, The distribution of the potential in a wedge, An application to the summation series, Finite Mellin transform.

Unit IV: Hankel Transform

Elementary properties of the Hankel transform, The Hankel inversion theorem, Hankel transforms of derivatives of functions, Hankel transforms of some elementary functions, The Parseval relation for Hankel transforms, Relations between Fourier and Hankel transforms, The modified operator of Hankel transforms, The use of Hankel transforms in the solution of partial differential equations. Finite Hankel transform.

Recommended Book:

1. I N. Sneddon, The use of integral transforms, Tata Mc Graw Hill Publishing Company Ltd.

Reference Book:

1. Edwin F Beckenbach, Modern Mathematics for Engineers, Second series, Mc Graw Hill Book Company.
2. L. Andrews and B. Shivanmogg, Integral Transforms for Engineers, Prentice Hall of India, 1999.

MMT3T03: MATLAB-PROGRAMMING

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Understand the basics of MATLAB coding and write the simple programs using MATLAB coding.

CO2. Creating vectors and matrices while performing the matrix operations to determine the better and more accurate solution by using MATLAB programming operations. Also, effectively use MATLAB coding to analyze and visualize data.

CO3. Solve the system of equation by using the basic element of MATLAB. Create simple graph plotting, labeling, curve fitting in MATLAB.

Unit I: Introduction of MATLAB

Basic commands, Built in function, Manipulating functions, Scripts, Files, Function files, Symbolic computations, Saving MATLAB sessions. **Loops:** For, While, Do…while, if, if … else.

Unit II: Matrices using MATLAB

Vectors and matrices, Creating vectors, Matrix operations like Addition, substraction, multiplication, inverse of a matrix, determinant of matrix, Eigen value, Eigen Vector,Solving and loading data, Import data files.

Unit III: Linear Systems using MATLAB

Solving linear systems as linear operator equations, Models in one dimension: Heat flow in a bar, Fourier's Law, Solving simple boundary value problems, existence and uniqueness of solution to $Ax = B$.

Reference Books:

1. Rudra Pratap, Getting started with Matlab: A quick introduction for scientist & engineers, Oxford, 2010.
2. Peter Issa Kattan, MATLAB for Beginners: A Gentle Approach.
3. B.R. Hunt, Jonathan Rosenberg and R.L. Lipsman, MATLAB for Beginners and Experienced Users.

MMT4L03: PRACTICAL 6 (MATLAB-PROGRAMMING)

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Understand the basics of MATLAB coding and write the simple programs using MATLAB coding.

CO2. Creating vectors and matrices while performing the matrix operations to determine the better and more accurate solution by using MATLAB programming operations. Also, effectively use MATLAB coding to analyze and visualize data.

CO3. Solve the system of equations by using the basic element of MATLAB. Create simple graph plotting, labeling, curve fitting in MATLAB.

Practical list:

1. Arithmetic Operation and Array
2. Basic Matrix operations and Element by Element matrix operation
3. Find the determinant of the matrix, Inverse of a matrix, Find Eigenvalue, Eigen Vector, Rank of a Matrix
4. Solve the simultaneous equation.
5. Plot 2D, 3D graphs
6. Pi diagram, Bar, histogram
7. MATLAB Programming with if, if … else statements
8. MATLAB Programming with For, While, Do…while loops
9. Solving System of Linear Algebraic equations
10. Curve fitting and Interpolation, Numerical differentiation

Reference Books:

1. Rudra Pratap, Getting started with Matlab: A quick introduction for scientist & engineers, Oxford, 2010.
2. Peter Issa Kattan, MATLAB for Beginners: A Gentle Approach.
3. B.R. Hunt, Jonathan Rosenberg and R.L. Lipsman, MATLAB for Beginners and Experienced Users.

MMT4E04: INDUSTRIAL PROCESSES

Course Learning Outcomes

After the successful completion of this course students develop the ability to apply various types of control charts in different industries. They also get theoretical knowledge and industrial application of the following topics and will be able to

- *CO1. Remember and classify various control charts for measurements and attributes useful in industries.*
- *CO2. Compare EWMA charts, multivariate control charts.*
- *CO3. Describe and interpret the working of quality systems ISO 9000 and QS 9000.*
- *CO4. Relate the use of design of experiments for quality improvement and process capability Analysis and implement it.*
- *CO5. Explain and apply the Taguchi philosophy , 6 sigma.*
- *CO6. At the end of this course students will be able to formulate the control limits and control charts required for the specification.*

Unit I:
Importance of Statistical methods in industries and Practice, General theory of control charts, Causes of variation in quality control limits, Charts for attributes P chart, np chart, c chart, Charts for variable's mean, range and S.D.

Unit II:
General ideas on economic designing of control chart. Assumptions and costs, Duncan's model for the economic design of X chart, Moving average and exponentially weighted moving average charts, Classification of nonconformities and their weighting modification of the c chart for Quality scores, Multivariate Quality control. Hotelling's T^2.

Unit III:
Quality Systems: ISO 9000 standards. QS 9000 standards, Total quality management (TQM) : Different definitions and dimensions of quality, TQM Models, Quality Management Tools, Six Sigma and Quality Management, What is Kaizen ? - Five S of Kaizen, Role of Managers in TQM, Role of Customers in Total Quality Management, Comparison of Six Sigma and TQM, Reasons for failure of TQM,

Unit IV:
Deming's 14 points program, Continuous quality improvement, PDSA cycle, Juran triology, Quality Gurus, Use of Design of experiments in SPC factorial experiments. Half fraction of Basic ideas of response surface methodology, Specification limits, Natural tolerance limits and control limits.

Recommended book:
1. Montgomery D.C. Introduction to statistical quality control. Wiley (1985).
2. Grant E. L. & Leaver worth R. S. statistical Quality control McGraHill publication.
3. Amitava Mitra: Fundamentals of quality control and improvement

Reference Books:
1. J. S.: Total quality management, Butterworth Heinemaah 14 (1989)
2. K. Shridhara Bhat: Total quality management, Himalaya Publishing House

MMT4E05: OPERATIONS REASERCH

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Formulate, analyze, and optimize transportation problems using LP techniques, including the transportation algorithm with considering time minimization and transhipment scenarios.

CO2. Incorporate mathematical formulation and solution methods for assignment problems while also comprehending the dual of the assignment method.

CO3. Analyze and solve two-person zero-sum games using the maximin-minimax principle, graphic solutions, dominance properties, and the arithmetic method, while determining the general solution for rectangular games.

CO4. Formulate and solve non-linear programming problems with constraints, including equality and inequality constraints, while understanding the concept of saddle points.

CO5. Understand probability theory in queueing systems, analyze operating characteristics, apply probability distributions, and utilize Poisson models.

Unit I:

Transportation Problem: LP formulation and the existence of a solution in transportation problem, Test for optimality, Transportation algorithm-MODI method, Stepping stone solution method, Some exceptional cases. Time minimization TP, Transshipment problem.

Assignment Problem: Mathematical formulation of the assignment problem, Solution methods, Special cases, A typical assignment problem, The traveling salesman problem

Unit II: Game Theory

Two-person zero-sum games, The maximin-minimax principle, Games without saddle points, Graphic solutions, Dominance property, Arithmetic method, General solution of $m \times n$ rectangular games, Game against passivity

Unit III: Non-linear programming

Formulation of non-linear programming problem, Constrained optimization with equality constraints, Constrained optimization with inequality constraints, Saddle point problem, Saddle point and NLPP.

Unit IV: Queueing Theory

Probability, Conditional probability, Random variables, Expectation of a random variable, Central tendency and dispersion, Elements of queueing system, Operating characteristics of queueing system, Probability distributions in queueing system, Classifications of queueing models, Definition of transient and steady states, Poisson queueing systems.

Recommended Book:

1. Kanti Swarup, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand and Sons New Delhi.

Reference Books:

1. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
2. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997
3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001

MMT4E07: CRYPTOGRAPHY

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Recall Divisibility and Euclidean algorithm.
CO2. Understand Public key cryptography, Hash function, Probabilistic encryption.
CO3. Differentiate Classical cryptosystems and RSA cryptosystems.
CO4. Execute Algorithms for discrete logarithm problem- Shank's algorithm.
CO5. Implement Elliptic curve cryptosystems.

Unit I:
Time estimates for doing arithmetic, Divisibility and Euclidean algorithm, Congruence's, quadratic residues and reciprocity, Fermat's little theorem, applications to factoring, finite fields**.**

Unit II:
Classical cryptosystems, Public key cryptography, Hash function, Probabilistic encryption, RSA cryptosystem, Pseudo primes, Pollard's P-1 method, The Rho method.

Unit III:
The El Gamal cryptosystem, Discrete logarithm, Diffee-Hellman key exchange system, Algorithms for discrete logarithm problem- Shank's algorithm, the Pollard Rhoalgorithm, the, Pohlig-Hellman Algorithm, Security of ElGamal systems, the ElGamal signature scheme.

Unit IV:
Elliptic curves, Elliptic curve cryptosystems, Elliptic curve primality test, Elliptic curve factorization.

Recommended Books:
1. Neal Koblitz, A Course in Number Theory and Cryptography (second edition), SpringerVerleg.
2. Douglas R. Stinson, Cryptography: Theory and practice (Third Edition), CRC Press.

Reference Book:
1. William Stallings, Cryptography and Network Security, Prentice Hall.

MMT4E07: NUMBER THEORY

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

CO1. Interpret the concepts of divisibility, prime number, congruence and number theorems.
CO2. To understand fundamental number-theoretic functions such as Mobius function, The Euler totient function.
CO3. Apply fundamentals for integer arithmetic
CO4. Apply mathematical ideas and concepts within the context of number theory.
CO5. Solve a range of problems in number theory.

Unit I:
The Mobius function u(n), The Euler totient function φ(n), A relation connecting φ and μ, A product formula for φ (n), The Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius Inversions formula, The Mangoldt function π(n), Multiplicative functions and Dirichlet multiplication, The inverse of a completely multiplicative function, Liouville's function (n), The divisor function (n), Generalized convolutions.

Unit II:
The big O notation Asymptotic equality of functions, Euler's summation formula, some elementary asymptotic formulas, The average order of d(n), the average order of divisor functions (n), the average order of φ(n), An application to the distribution of lattice points visible from the origin, The average order of μ(n) and π(n), The partial sums of a Dirichlet product, Applications to μ(n) and π(n), Another identity for the partial sums of a Dirichlet product.

Unit III: Galois Theory
Chebyshev's functions Ψ(x) and v(x), Relations connecting Ψ (x) and v(x), Some equivalent forms of the prime number theorem, Inequalities of π(n) and P_n Shapiro's Tauberian theorem, Application of Shapiro's theorem, An asymptotic formulae for the partial sums ∑ (1/p).

Unit IV: Applications of Galois theory to classical problems
Definition and basic properties of congruences, Residue classes and complete residue systems, Linear congruences, Reduced residue systems and Euler - Format theorem, Polynomial congruences modulo p, Lagrange's theorem, Simultaneous linear congruences, the Chinese remainder theorem, Applications of the Chinese remainder theorem, Polynomial congruences with prime power moduli.

Recommended Book:
Introduction to analytic number theory - by Tom M-Apostol, Narosa Publishing House, New Delhi.

Reference Books:
D.M. Burton, Introduction to Number Theory, McGraw-Hill.