Indira Gandhi University, Meerpur (Rewari)

Scheme of Examination and Syllabi

for

M.Sc.(Mathematics) Ist Semester

w.e.f. session 2019-20

as per

Choice Based Credit System (CBCS)

Indira Gandhi University, Meerpur (Rewari)
Scheme of Examination
M.Sc. Mathematics
Under Choice Based Credit System
w.e.f. Session 2019-20

Semester-I

Core Courses

Course Code	Title of the Course	Theory Marks	Internal Marks	Practical Marks	Credits L:T:P	Contact hrs per week	Total Credits
MAT-101	Abstract Algebra	80	20	-	4:0:0	4	4
MAT-102	Mathematical Analysis	80	20	-	4:0:0	4	4
MAT-103	Ordinary Differential Equations	80	20	-	4:0:0	4	4
MAT-104	Complex Analysis	80	20	-	4:0:0	4	4
MAT-105	Mathematical Statistics	80	20	-	4:0:0	4	4
MAT-106	Computer Applications	60	-	40	2:0:2	6	4
MAT-107	Mathematical Lab-I	-	-	50	0:0:2	4	2
MAT-108	Seminar	-	-	25	-	-	1
MAT-109	Self Study Paper	-	-	25	-	-	1

Total Credits : 28
Total Contact Hours per Week : 30
Max Marks : 700

Note: The criteria for awarding internal assessment of 20 marks for each paper shall be as under :

(i) Sessional test : 10 marks
(ii) Assignment/Presentation : 5 marks
(iii) Attendance : 5 marks
Less than 65% : 0 marks
65% and above but upto 70% : 2 marks
Above 70% but upto 75% : 3 marks
Above 75% but upto 80% : 4 marks
Above 80% : 5 marks

General Guidelines

1. Seminar

In each semester, there will be a paper on seminar presentation of 25 marks with 01 credit. In this paper, the student will be required to present a seminar of about 15-20 minutes on the theme/topic such as review of research papers/articles published in National/International Journals in his /her area of interest. The topic will be selected by the student in consultation with the teacher alloted to him/her by the department.

An internal committee of two teachers constituted by the Chairperson of the department for each student will evaluate the seminar presentation. The evaluation (Internal evaluation only) will be based on the presentation of student, depth of subject matter and answer to questions. There will be a Coordinator to be nominated by the Chairperson of the Department among the teachers of the Department.

For seminar, the topics should be chosen in the following manner:

1st Semester	Any topic (not related to the syllabi)
2nd Semester	Any Basic Research Paper/Article
3rd Semester	Any National Level Research Paper/Article
4th Semester	Any Foreign Research Paper/Article

2. Self Study Paper

In each semester, there will be a self study paper of 25 marks with 01 credit. The objective of this paper is to create habits of reading books and to develop writing skills in a manner of creativity and originality. The students will select a topic of their own interest in the given area in consulation with their teachers/incharge/mentors. After selecting a suitable title for the paper, the students will be required to prepare a hand written report of about 6-10 pages in his/her own handwritng. The students will be required to submit the report after getting it checked by the concerned teacher and will be asked to re-submit the report after making the required corrections(if any) before the commencment of the examinations of that semester. The structure of the paper will include the following:

- Introduction
- Main Body
- Conclusion

The thoughts presented in the paper must be original work of the students.

The paper will be evaluated by the panel (one external and one internal examiner) to be appointed by the Chairperson of Department from the prescribed panel of the University.

The evaluation of Self Study paper will be done as given below:

- Evaluation of the paper : 15 marks
- Viva-Voce on the paper : 10 marks
- Total : 25 marks

MAT-101: Abstract Algebra

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

p-groups, Sylow p-subgroups, Sylow theorems, Applications of Sylow theorems, Description of groups of order p^2 and pq, Survey of groups upto order 15.

Section-II

Normal and subnormal series, Solvable series, Derived series, Solvable groups, Solvability of S_n-the symmetric group of degree n $\geq$2, Central series, Nilpotent groups and their properties, Upper and lower central series.
Composition series, Zassenhaus lemma, Jordan-Holder theorem.

Section-III

Modules, Cyclic modules, Simple modules, Schur lemma, Free modules, Torsion modules, Torsion free modules, Fundamental structure theorem for finitely generated free modules, Modules over principal ideal domain and its applications to finitely generated abelian groups.

Section-IV

Noetherian and Artinian modules, Noetherian and Artinian rings, Nil and nilpotent ideals in Noetherian and Artinian rings, Hilbert basis theorem.
Hom_R(R,R), Opposite rings, Wedderburn-Artin theorem, Maschke theorem.

Books recommended

1. I. S. Luther and I.B.S. Passi, Algebra, Vol. I-Groups, Narosa Publishing House, 2013.
2. I. S. Luther and I.B.S. Passi, Algebra, Vol. III-Modules, Narosa Publishing House, 2013.
3. Charles Lanski, Concepts in Abstract Algebra, American Mathematical Society, First Indian Edition, 2010.
4. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
5. D. S. Malik, J. N. Mordenson and M. K. Sen, Fundamentals of Abstract Algebra, McGraw-Hill International Edition, 1997.
6. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition, 1997.
7. C. Musili, Introduction to Rings and Modules, Narosa Publication House, 1994.
8. N. Jacobson, Basic Algebra, Vol. I and II, W.H Freeman, 1980.
9. M. Artin, Algebra, Prentice-Hall of India, 1991.
10. Ian D. Macdonald, The Theory of Groups, Clarendon Press, 1968.

MAT-102: Mathematical Analysis

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

Riemann-Stieltjes integral, Existence and properties, Integration and differentiation, The fundamental theorem of calculus, Integration of vector-valued functions, Rectifiable curves.

Section-II

Sequence and series of functions, Pointwise and uniform convergence, Cauchy criterion for uniform convergence, M_n-test for uniform convergence, Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence, Uniform convergence and continuity, Uniform convergence and Integration, Uniform convergence and differentiation, Weierstrass approximation theorem.

Section-III

Power series, uniform convergence and uniqueness theorem, Abel's theorem, Tauber's theorem.

Functions of several variables, Linear Transformations, Euclidean space R^n, Derivatives in an open subset of R^n, Chain Rule, Partial derivatives, Continuously Differentiable Mapping, Young and Schwarz theorems.

Section-IV

Taylor theorem, Higher order differentials, Explicit and implicit functions, Implicit function theorem, Inverse function theorem, Change of variables, Extreme values of explicit functions, Stationary values of implicit functions, Lagrange multipliers method, Jacobian and its properties.

Books recommended

1. Walter Rudin, Principles of Mathematical Analysis (3rd edition) McGraw-Hill, International Student Edition, 1976.
2. T. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1974.
3. H. L. Royden, Real Analysis, Macmillan Pub. Co., Inc. 4th Edition, New York, 1993.
4. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH Pub. Co. Pvt. Ltd, 1976.
5. R. G. Bartle, The Elements of Real Analysis, Wiley International Edition, 2011.
6. S. C. Malik and Savita Arora, Mathematical Analysis, New Age International Limited, New Delhi, 2012.

MAT-103: Ordinary Differential Equations

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

Preliminaries, ϵ-approximate solution, Cauchy-Euler construction of an ϵ-approximate solution of an initial value problem, Equicontinuous family of functions, Ascoli-Arzela Lemma, Cauchy-Peano existence theorem.

Lipschitz condition, Picard-Lindelof existence and uniqueness theorem for $\frac{dy}{dt} = f(t, y)$, Solution of initial-value problems by Picard's method, Dependence of solutions on initial conditions.
(Relevant topics from the books by Coddington and Levinson, and Ross).

Section-II

Linear systems, Matrix method for homogeneous first order system of linear differential equations, Basic theory of the homogeneous linear system, Fundamental set of solutions, Fundamental matrix of solutions, Wronskian of solutions, Abel-Liouville formula, Non-homogeneous linear system.
Strum Theory: Self-adjoint equations of the second order, Some basic results of Sturm theory, Abel's formula, Strum Separation theorem, Strum's Fundamental comparison theorem.
(Relevant topics from chapters 7 and 11 of book by Ross)

Section-III

Nonlinear differential systems, Phase plane, Path, Critical points, Autonomous systems, Isolated critical point, Path approaching a critical point, Path entering a critical point, Types of critical points - Center, Saddle points, Spiral points, Node points. Stability of critical points, Stable critical points, Asymptotically stable critical points, Unstable critical points, Critical points and paths of linear systems.
(Relevant topics from chapter 13 of book by Ross).

Section-IV

Almost linear systems, Critical points and paths of almost linear systems, Nonlinear conservative dynamical systems, Dependence on a parameter, Liapunov's direct method.
Limit Cycles and Periodic solutions: Limit cycles, Periodic solutions, Existence and nonexistence of limit cycles, Bendixson's nonexistence criterion, Poincare-Bendixson theorem (statement only), Index of a critical point.

Strum-Liouville problems, Orthogonality of characteristic functions.
(Relevant topics from chapters 12 and 13 of the book by Ross).

Books recommended

1. E. A. Coddington and N. Levinson, Theory of ordinary differential equations, Tata McGraw Hill, 2000.

2. S. L. Ross, Differential equations, John Wiley and Sons Inc., New York, 1984.

3. W. E. Boyce and R. C. Diprima, Elementary differential equations and boundary value problems, John Wiley and Sons, Inc., New York, 4th edition, 1986.

4. G. F. Simmon, Differential Equations, Tata McGraw Hill, New Delhi, 1993.

MAT-104: Complex Analysis

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

Functions of a complex variable, Continuity, Differentiability, Analytic functions and their properties, Cauchy-Riemann equations in Cartesian and polar coordinates.

Power series, Radius of convergence, Differentiability of sum function of a power series, Branches of many valued functions with special reference to arg$z$, Log$z$ and z^a.

Section-II

Path in a region, Contour, Complex integration, Cauchy theorem, Cauchy integral formula, Extension of Cauchy integral formula for multiple connected domain, Poisson integral formula, Higher order derivatives, Complex integral as a function of its upper limit, Morera theorem, Cauchy inequality, Liouville theorem, Taylor theorem.

Section-III

Zeros of an analytic function, Laurent series, Isolated singularities, Cassorati-Weierstrass theorem, Limit point of zeros and poles. Maximum modulus principle, Schwarz lemma, Meromorphic functions, Argument principle, Rouche theorem, Fundamental theorem of algebra, Inverse function theorem.

Section-IV

Calculus of residues, Cauchy residue theorem, Evaluation of integrals of the types

$$\int_0^{2\pi} f(\cos\theta, \sin\theta)d\theta, \ \int_{-\infty}^{\infty} f(x)dx, \ \int_0^{\infty} f(x)\sin mx\ dx \ \text{ and } \int_0^{\infty} f(x)\cos mx\ dx.$$

Conformal mappings, Space of analytic functions and their completeness, Hurwitz theorem, Montel theorem, Riemann mapping theorem.

Books recommended

1. H. A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
2. J. B. Conway, Functions of One Complex Variable, Springer-Verlag, International Student Edition, Narosa Publishing House, 2002.
3. Ruel V. Churchill and James Ward Brown, Complex Variables and Applications, McGraw-Hill Publishing Company, 2009.
4. E. T. Copson, An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, London, 1972.

5. E. C. Titchmarsh, The Theory of Functions, Oxford University Press, London.

6. H. S. Kasana, Complex Variables: Theory and Applications, PHI Learning Private Ltd, 2013.

7. Dennis G. Zill and P. D. Shanahan, A First Course in Complex Analysis with Applications, John Bartlett Publication, 2nd Edition, 2010.

MAT-105: Mathematical Statistics

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

Probability: Definition and various approaches of probability, Addition theorem, Boole's inequality, Conditional probability and multiplication theorem, Independent events, Mutual and pairwise independence of events, Bayes' theorem and its applications.

Section-II

Random variable and probability functions: Definition and properties of random variables, Discrete and continuous random variables, Probability mass and density functions, Distribution function, Concepts of bivariate random variable: joint, marginal and conditional distributions.
Mathematical expectation: Definition and its properties, Variance, Covariance, Moment generating function- Definitions and their properties.

Section-III

Discrete distributions: Uniform, Bernoulli, Binomial, Poisson and Geometric distributions with their properties.
Continuous distributions: Uniform, Exponential and Normal distributions with their properties.

Section-IV

Testing of hypothesis: Parameter and statistic, Sampling distribution and standard error of estimate, Null and alternative hypotheses, Simple and composite hypotheses, Critical region, Level of significance, One tailed and two tailed tests, Two types of errors.
Tests of significance: Large sample tests for single mean, Single proportion, Difference between two means and two proportions.

Books recommended

1. A. M. Mood, F. A. Graybill, and D. C. Boes, Introduction to the Theory of Statistics, McGraw-Hill,1974.
2. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.
3. J. E. Freund, Mathematical Statistics, Prentice Hall College Div, 1992.
4. M. Spiegel, Probability and Statistics, Schaum Outline Series.

MAT-107: Mathematical Lab-I

Max. Marks : 50
Credits : 0:0:2

Mathematical problem solving techniques based on paper MAT-101 to MAT-105 will be taught. There will be problems based on 5-6 problem solving techniques from each paper.

Note: Every student will have to maintain practical record of atleast 25 problems solved during practical class work in a file. Examination will be conducted through a question paper set jointly by the external and internal examiners. The question paper will consists of four questions based on problem solving techniques/algorithm. An examinee will be asked to write the solutions of any two in the answer book. Evaluation will be made on the basis of the examinee's performance in written solutions, practical record and viva-voce.

Practical examination will be conducted as per the following distribution of marks:
Writing solutions of problems : 20 marks
Viva Voce : 20 marks
Practical record : 10 marks.

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Semester-II

Core Courses

Course Code	Title of the Course	Theory Marks	Internal Marks	Practical Marks	Credits L:T:P	Contact hrs per week	Total Credits
MAT-201	Field Extensions and Galois Theory	80	20	-	4:0:0	4	4
MAT-202	Measure and Integration Theory	80	20	-	4:0:0	4	4
MAT-203	Integral Equations and Calculus of Variations	80	20	-	4:0:0	4	4
MAT-204	General Topology	80	20	-	4:0:0	4	4
MAT-205	Computing Lab-I (Documentation in LaTex)	-	-	50	0:0:2	4	2
MAT-206	Seminar	-	-	25	-	-	1
MAT-207	Self Study Paper	-	-	25	-	-	1

Discipline Centric Elective Courses (Any one)

Course Code	Title of the Course	Theory Marks	Internal Marks	Credits L:T:P	Contact hrs per week	Total Credits
MAT-208	Operations Research Techniques	80	20	4:0:0	4	4
MAT-209	Information Theory	80	20	4:0:0	4	4

Foundation Elective Courses (Any one)

Course Code	Title of the Course	Theory Marks	Internal Marks	Credits L:T:P	Contact hrs per week	Total Credits
MAT-210	Value Education	40	10	2:0:0	2	2
MAT-211	Communication Skills and Personality Development	40	10	2:0:0	2	2

Total Credits : 26
Total Contact Hours per Week : 26
Max Marks : 650

General Guidelines

1. Seminar

In each semester, there will be a paper on seminar presentation of 25 marks with 01 credit. In this paper, the student will be required to present a seminar of about 15-20 minutes on the theme/topic such as review of research papers/articles published in National/International Journals in his /her area of interest. The topic will be selected by the student in consultation with the teacher alloted to him/her by the department.

An internal committee of two teachers constituted by the Chairperson of the department for each student will evaluate the seminar presentation. The evaluation (Internal evaluation only) will be based on the presentation of student, depth of subject matter and answer to questions. There will be a Coordinator to be nominated by the Chairperson of the Department among the teachers of the Department.

For seminar, the topics should be chosen in the following manner:

1st Semester	Any topic (not related to the syllabi)
2nd Semester	Any Basic Research Paper/Article
3rd Semester	Any National Level Research Paper/Article
4th Semester	Any Foreign Research Paper/Article

2. Self Study Paper

In each semester, there will be a self study paper of 25 marks with 01 credit. The objective of this paper is to create habits of reading books and to develop writing skills in a manner of creativity and originality. The students will select a topic of their own interest in the given area in consulation with their teachers/incharge/mentors. After selecting a suitable title for the paper, the students will be required to prepare a hand written report of about 6-10 pages in his/her own handwritng. The students will be required to submit the report after getting it checked by the concerned teacher and will be asked to re-submit the report after making the required corrections(if any) before the commencment of the examinations of that semester. The structure of the paper will include the following:

- Introduction
- Main Body
- Conclusion

The thoughts presented in the paper must be original work of the students.

The paper will be evaluated by the panel (one external and one internal examiner) to be appointed by the Chairperson of Department from the prescribed panel of the University.

The evaluation of Self Study paper will be done as given below:

- Evaluation of the paper : 15 marks
- Viva-Voce on the paper : 10 marks
- Total : 25 marks

MAT-201: Field Extensions and Galois Theory

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

Fields, Prime fields, Finite field extensions, Degree of field extensions, Simple Extensions, Algebraic extensions, Splitting fields, Algebraically closed fields.

Section-II

Separable and inseparable extensions, Perfect fields.

Monomorphisms and their linear independence, Automorphism of fields, Fixed fields, Normal extensions, The fundamental theorem of Galois theory.

Section-III

Finite fields, Existence of GF(p^n), Construction of finite fields, Primitive elements, Langrage's theorem on primitive elements, Roots of unity, Cyclotomic polynomials, Cyclotomic extensions of rational number field.

Section-IV

Solutions by radicals, Extension by radicals, Generic polynomial, Insolvability of the general polynomial of degree $n \geq 5$ by radicals, Ruler and compasses construction.

Books recommended

1. I. S. Luther and I.B.S.Passi, Algebra, Vol. IV-Field Theory, Narosa Publishing House, 2012.
2. Ian Stewart, Galois Theory, Chapman and Hall/CRC, 2004.
3. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
4. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition, 1997.
5. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.
6. Ian T. Adamson, Introduction to Field Theory, Cambridge University Press, 1982.
7. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.

MAT-202: Measure and Integration Theory

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

Set functions, Intuitive idea of measure, Elementary properties of measure, Measurable sets and their fundamental properties. Lebesgue measure of sets of real numbers, Algebra of measurable sets, Borel sets and their measurability, Equivalent formulation of measurable sets in terms of open, closed, F_σ and G_δ sets, Non-measurable sets.

Section-II

Measurable functions and their equivalent formulations, Properties of measurable functions, Approximation of a measurable function by a sequence of simple functions, Measurable functions as nearly continuous functions, Egoroff's theorem, Lusin's theorem, Convergence in measure and F. Riesz theorem for convergence in measure, Almost uniform convergence.

Section-III

Shortcomings of Riemann Integral, Lebesgue Integral of a bounded function over a set of finite measure and its properties, Lebesgue integral as a generalization of Riemann integral, Bounded convergence theorem, Integral of non-negative functions, Fatou's Lemma, Monotone convergence theorem, General Lebesgue Integral, Lebesgue convergence theorem.

Section-IV

Vitali's covering lemma, Differentiation of monotonic functions, Functions of bounded variation and their representation as difference of monotonic functions, Differentiation of indefinite integral, Fundamental theorem of calculus, Absolutely continuous functions and their properties, Convex functions, Jensen's Inequality.

Books recommended

1. H. L. Royden, Real Analysis, Macmillan Pub. Co., Inc. 4th Edition, New York, 1993.
2. P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, New Age International (P) Limited Published, New Delhi, 1986.
3. G. De Barra, Measure Theory and Integration, Wiley Eastern Ltd., 1981.
4. Walter Rudin, Principles of Mathematical Analysis (3rd edition) McGraw-Hill, Kogakusha, 1976, International Student Edition.
5. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH Pub. Co. Pvt. Ltd, 1976.
6. R. G. Bartle, The Elements of Real Analysis, Wiley International Edition, 2011.

MAT-203: Integral Equations and Calculus of Variations

Time : 3 hours **Max. Marks : 80**

Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

Linear Integral equations, Some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations, Resolvent kernel as a series, Laplace transform method for a difference kernel, Solution of a Volterra integral equation of the first kind.

Section-II

Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm equations of second kind, Iterated kernels and Neumann series for Fredholm equations, Resolvent kernel as a sum of series, Fredholm resolvent kernel as a ratio of two series, Fredholm equations with separable kernels, Approximation of a kernel by a separable kernel, Fredholm Alternative, Non homogeneous Fredholm equations with degenerate kernels.

Section-III

Green's function, Use of method of variation of parameters to construct the Green's function for a non-homogeneous linear second order boundary value problem, Basic four properties of the Green's function, Alternate procedure for construction of the Green's function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green's function, Hilbert-Schmidt theory for symmetric kernels.

Section-IV

Motivating problems of calculus of variations, Shortest distance, Minimum surface of resolution, Brachistochrone problem, Isoperimetric problem, Geodesics, Fundamental lemma of calculus of variations, Euler's equation for one dependant function and its generalization to 'n' dependant functions and to higher order derivatives, Conditional extremum under geometric constraints and under integral constraints.

Books recommended

1. A. J. Jerri, Introduction to Integral Equations with Applications, A Wiley Interscience Publication, 1999.
2. R. P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York.
3. J. M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall, New Jersy, 1963.
4. W. V. Lovitt, Linear Integral Equations, McGraw Hill, New York.
5. F. B. Hilderbrand, Methods of Applied Mathematics, Dover Publications.

MAT-204: General Topology

Time : 3 hours **Max. Marks : 80**

Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

Definition and examples of topological spaces, Comparison of topologies on a set, Intersection and union of topologies on a set, Limit point of a set, Derived set, Closed set, Closure of a set, Kuratowski closure axioms, Closure operator, Dense sets, Interior point and Interior of a set, Interior axioms, Exterior of a set, Exterior axioms, Boundary of a set, Interior, exterior and boundary operators, Neighborhoods, Alternative methods of defining a topology in terms of neighborhood system and Kuratowski closure operator.

Section-II

Relative (Induced) topology, Base and subbase for a topology, Base for neighbourhood system.

Continuous functions, Composition of continuous functions, Pasting lemma, Open and closed functions, Homeomorphisms, Topological properties.

Connectedness and its characterization, Connected subsets and their properties, Continuity and connectedness, Components, Locally connected spaces.

Section-III

Separation axioms: T_0, T_1, T_2-spaces, their characterization and basic properties, T_2-spaces and sequences.

First countable, Second countable and Separable spaces, Hereditary and topological property, Countability of a collection of disjoint open sets in separable and second countable spaces, Lindelöf theorem.

Section-IV

Compact spaces and subsets, Compactness in terms of finite intersection property, Continuity and compact sets, Basic properties of compactness, Closedness of compact subset of a Hausdorff space and of a continuous map from a compact space into a Hausdorff and its consequence. Sequentially and Countably compact spaces, Locally compact spaces and One point compactification.

Books recommended

1. W. J. Pervin, Foundations of General Topology, Academic Press Inc. New York, 1964.
2. C. W. Patty, Foundation of Topology, Jones and Bartlett, 2009.
3. Fred H. Croom, Principles of Topology, Cengage Learning, 2009.
4. K. D. Joshi, Introduction to General Topology, New Age International, 1983.
5. J. L. Kelly, General Topology, Springer Verlag, New York, 2000.
6. J. R. Munkres, Topology, Pearson Education, 2002.
7. K. Chandrasekhara Rao, Topology, Alpha Science International, 2009.

MAT-205: Computing Lab-I (Documentation in LaTex)

Time : 4 hours **Max. Marks : 50**

Credits : 0:0:2

Note: (A) Each candidate will be provided a question paper of four questions and will be required to attempt two questions. The candidate will first prepare the docoment in LaTex of the questions in the answer-book and then run the same on the computer, and then finally add the print-outs of these programs in the answer-book. This work will consist of 30 marks, 15 marks for each question.

(B) The practical file of each student will be checked and Viva-Voce examination based upon the practical file and the theory will be jointly conducted by external and internal examiners. This part of the practical examination shall be of 20 marks.

List of Practicals

1. Create a document in LaTeX to output the following:

   Hello World! Today I am learning LaTeX. LaTeX is a great program for writing math. I can write in line math such as $a^2 + b^2 = c^2$. I can also write equation in a new line:

   $$\gamma^2 + \theta^2 = \omega^2$$

2. Write a program in LaTeX to output the following:

   $$\begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix} \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix} = \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix}$$

3. Write a program in LaTeX to obtain the following output:

   $$a_1x + b_1y + c_1z = d_1$$
   $$a_2x + b_2y + c_2z = d_2$$
   $$a_3x + b_3y + c_3z = d_3$$

4. Write a program in LaTeX to obtain the following output:
   Find the solution of the Laplace Equation

   $$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$$

   in the rectangle $0 \le x \le a, 0 \le y \le b$ satisfying the boundary conditions

   $$u(x, 0) = 0, u(x, b) = 0$$

   $$u(0, y) = 0, u(a, y) = f(y)$$

5. Write a program in LaTeX to create the following table:

Table 1: This is a table

x	1	2	3
$f(x)$	4	8	12
f(x)	4	8	12

6. Write a program in LaTeX with the following output:

$$\int_a^b x\,dx = \left.\frac{x^2}{2}\right|_a^b$$

$$\iiint_V f(x,y,z)\,dV = F$$

7. Write a program in LaTeX with the following output:

$$\frac{df}{dx} = f'(x) = \lim_{h\to 0}\frac{f(x+h)-f(x)}{h}$$

$$|x| = \begin{cases} -x, & \text{if } x < 0 \\ x, & \text{if } x \geq 0 \end{cases}$$

8. Write a program in LaTeX with the following output:

$$F(x) = A_0 + \sum_{n=1}^{N}\left[A_n\cos\left(\frac{2\pi nx}{P}\right) + B_n\sin\left(\frac{2\pi nx}{P}\right)\right]$$

$$\sum_n \frac{1}{n^s} = \prod_p \frac{1}{1-\frac{1}{p^s}}$$

9. Write a program in LaTeX with the following output:

$$\begin{aligned} f(x) &= x^2 + 3x + 5x^2 + 8 + 6x && (0.0.1)\\ &= 6x^2 + 9x + 8 && (0.0.2)\\ &= x(6x+9) + 8 && (0.0.3) \end{aligned}$$

10. Write a program in LaTeX with the following output:

$$X = \frac{F_0}{k}\frac{1}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}}$$

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}$$

11. Write a program in LaTeX with the following output:

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

$SO_4^{2-} + Ba^{2+} \rightarrow BaSO_4$

12. Write a program in LaTeX with the following output:

$\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u} \cdot \nabla)\mathbf{u} - \nu\nabla^{\mathbf{2}}(\mathbf{u}) = -\nabla \mathbf{h}$

$m\ddot{x} + c\dot{x} + kx = F_0 \sin(2\pi f t)$

$\alpha A \beta B \gamma \Gamma \delta \Delta \pi \Pi \omega \Omega$

13. Write a program in LaTeX with the following output:

"Maxwell's equations" are named for James Clark Maxwell and are as follows:

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0} \qquad \text{Gauss's Law} \qquad (0.0.4)$$

$$\vec{\nabla} \cdot \vec{B} = 0 \qquad \text{Gauss's Law for Magnetism} \qquad (0.0.5)$$

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \qquad \text{Faraday's Law of Induction} \qquad (0.0.6)$$

$$\vec{\nabla} \times \vec{B} = \mu_0 \left(\epsilon_0 \frac{\partial \vec{E}}{\partial t} + \vec{J} \right) \qquad \text{Ampere's Circuital Law} \qquad (0.0.7)$$

Equations (0.0.4), (0.0.5), (0.0.6), and (0.0.7) are some of the most important equations in Physics.

14. Write a program in LaTeX with the following output:

$$\begin{array}{r} \mathbf{8} \\ \times\ \mathbf{5} \\ \hline \mathbf{40} \end{array}$$

15. Write a program in LaTeX with the following output:
Let f and g be bounded measurable functions defined on a set E of finite measure. Then

$$\int_E f + g = \int_E f + \int_E g.$$

If $f_n \xrightarrow{m} f$ and $g_n \xrightarrow{m} g$, then show that $f_n + g_n \xrightarrow{m} f + g$.

16. Write a program in LaTeX to display your own photograph.

MAT-208: Operations Research Techniques

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

Operations Research: Origin, Definition and scope.
Linear Programming: Formulation and solution of linear programming problems by graphical and simplex methods, Big-M and two-phase methods, Degeneracy, Duality in linear programming.

Section-II

Transportation Problems: Basic feasible solutions, Optimum solution by stepping stone and modified distribution methods, Unbalanced and degenerate problems, Transshipment problem.
Assignment problems: Solution by Hungarian method, Unbalanced problem, Case of maximization, Travelling salesman and crew assignment problems.

Section-III

Queuing models: Basic components of a queuing system,Concepts of stochastic processes, Poisson process, Birth-death process. Steady-state solution of Markovian queuing models with single and multiple servers (M/M/1, M/M/C, M/M/1/k, M/MC/k).
Sequencing problems: Solution of sequecing problems, processing n jobs through 2 machines, n jobs through 3 machines, n jobs through m machines, 2 jobs through m machines.

Section-IV

Inventory control models: Economic order quantity(EOQ) model with uniform demand and with different rates of demands in different cycles, EOQ when shortages are allowed, EOQ with uniform replenishment, Inventory control with price breaks.
Game Theory: Two person zero sum game, Game with saddle points, The rule of dominance, Algebraic, Graphical and linear programming methods for solving mixed strategy games.

Books recommended

1. H. A. Taha, Operations Research-An Introduction, Prentice Hall, 1997.
2. P. K. Gupta and D.S. Hira, Operations Research, S. Chand and Co. Ltd., 2014.
3. S. D. Sharma, Operations Research, Kedar Nath Ram Nath Publications.
4. J. K. Sharma, Mathematical Models in Operations Research, Tata McGraw-Hill Publishing Company Ltd., 1989.
5. Kanti Swarup, P. K. Gupta and ManMohan, Operations Research, Sultan Chand and Sons, New Delhi, 2005.

MAT-209: Information Theory

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Section-I

Measure of information Axioms for a measure of uncertainty. The Shannon entropy and its properties. Joint and conditional entropies. Trans-information and its properties. Axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.

Section-II

Noiseless coding - Ingredients of noiseless coding problem. Uniquely decipherable codes. Necessary and sufficient condition for the existence of instantaneous codes. Construction of optimal codes.

Section-III

Discrete memoryless channel - Classification of channels. Information processed by a channel. Calculation of channel capacity. Decoding schemes. The ideal observer. The fundamental theorem of information theory.

Section-IV

Continuous channels - The time-discrete Gaussian channel. Uncertainty of an absolutely continuous random variable. The converse to the coding theorem for time-discrete Gaussian channel. The time-continuous Gaussian channel. Band-limited channels.

Books recommended

1. R. Ash, Information Theory, Interscience Publishers, New York, 1965.
2. F.M. Reza, An Introduction to Information Theory, MacGraw-Hill Book Company Inc., 1961.
3. J. Aczela dn Z. Daroczy, On Measures of Information and their Characterizations, Academic Press, New York.

Indira Gandhi University, Meerpur (Rewari)

Scheme of Examination and Syllabi

for

M.Sc.(Mathematics) 3rd Semester

w.e.f. session 2020-21

as per

Choice Based Credit System (CBCS)

Indira Gandhi University, Meerpur (Rewari)
Scheme of Examination
M.Sc. Mathematics
Under Choice Based Credit System
w.e.f. Session 2020-21

Semester-III

Core Courses

Course Code	Title of the Course	Theory Marks	Internal Marks	Practical Marks	Credits L:T:P	Contact hrs per week	Total Credits
MAT-301	Functional Analysis	80	20	-	4:0:0	4	4
MAT-302	Advanced Topology	80	20	-	4:0:0	4	4
MAT-303	Fluid Dynamics	80	20	-	4:0:0	4	4
MAT-304	Mathematical Lab-II	-	-	50	0:0:2	4	2
MAT-305	Seminar	-	-	25	-	-	1
MAT-306	Self Study Paper	-	-	25	-	-	1

Discipline Centric Elective Courses (Any two)

Course Code	Title of the Course	Theory Marks	Internal Marks	Credits L:T:P	Contact hrs per week	Total Credits
MAT-307	Discrete Mathematics	80	20	4:0:0	4	4
MAT-308	Fuzzy Set Theory	80	20	4:0:0	4	4
MAT-309	Mechanics of Solids	80	20	4:0:0	4	4
MAT-310	Analytical Number Theory	80	20	4:0:0	4	4
MAT-311	Partial Differential Equations	80	20	4:0:0	4	4
MAT-312	Difference Equations	80	20	4:0:0	4	4
MAT-313	Mathematical Modeling	80	20	4:0:0	4	4
MAT-314	Computational Fluid Dynamics	80	20	4:0:0	4	4

Open Elective Course

To be chosen from the pool of open elective courses provided by the University (excluding the open elective course offered by the Department of Mathematics)	Max. Marks 100	Credits 3

Open Elective Course offered by the Department of Mathematics

Course Code	Title of the Course	Theory Marks	Internal Marks	Credits L:T:P	Contact hrs per week	Total Credits
MAT-315	Basics of Vedic Mathematics	80	20	3:0:0	3	3

Total Credits : 27
Total Contact Hours per Week : 27
Max Marks : 700

Note: Optional papers can be offered subject to the availability of requisite resources/faculty.

General Guidelines

1. Seminar

In each semester, there will be a paper on seminar presentation of 25 marks with 01 credit. In this paper, the student will be required to present a seminar of about 15-20 minutes on the theme/topic such as review of research papers/articles published in National/International Journals in his /her area of interest. The topic will be selected by the student in consultation with the teacher alloted to him/her by the department.

An internal committee of two teachers constituted by the Chairperson of the department for each student will evaluate the seminar presentation. The evaluation (Internal evaluation only) will be based on the presentation of student, depth of subject matter and answer to questions. There will be a Coordinator to be nominated by the Chairperson of the Department among the teachers of the Department.

For seminar, the topics should be chosen in the following manner:

1st Semester	Any topic (not related to the syllabi)
2nd Semester	Any Basic Research Paper/Article
3rd Semester	Any National Level Research Paper/Article
4th Semester	Any Foreign Research Paper/Article

2. Self Study Paper

In each semester, there will be a self study paper of 25 marks with 01 credit. The objective of this paper is to create habits of reading books and to develop writing skills in a manner of creativity and originality. The students will select a topic of their own interest in the given area in consulation with their teachers/incharge/mentors. After selecting a suitable title for the paper, the students will be required to prepare a hand written report of about 6-10 pages in his/her own handwritng. The students will be required to submit the report after getting it checked by the concerned teacher and will be asked to re-submit the report after making the required corrections(if any) before the commencment of the examinations of that semester. The structure of the paper will include the following:

- Introduction
- Main Body
- Conclusion

The thoughts presented in the paper must be original work of the students.

The paper will be evaluated by the panel (one external and one internal examiner) to be appointed by the Chairperson of Department from the prescribed panel of the University.

The evaluation of Self Study paper will be done as given below:

- Evaluation of the paper : 15 marks
- Viva-Voce on the paper : 10 marks
- Total : 25 marks

MAT-301: Functional Analysis

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Normed linear spaces, Metric on normed linear spaces, Completion of a normed space, Banach spaces, subspace of a Banach space, Holder's and Minkowski's inequality, Completeness of quotient spaces of normed linear spaces. Completeness of l^p, L^p, R^n, C^n and $C[a, b]$. Incomplete normed spaces.

Section-II

Finite dimensional normed linear spaces and subspaces, Bounded linear transformation, Equivalent formulation of continuity, Spaces of bounded linear transformations, Continuous linear functional, Conjugate spaces, Hahn-Banach extension theorem (Real and Complex form).

Section-III

Riesz Representation theorem for bounded linear functionals on L^p and $C[a, b]$. Second conjugate spaces, Reflexive space, Uniform boundedness principle and its consequences, Open mapping theorem and its application, Projections, Closed Graph theorem.

Section-IV

Equivalent norms, Weak and Strong convergence, their equivalence in finite dimensional spaces.

Compact Operator and its relation with continuous operator, Compactness of linear transformation on a finite dimensional space, properties of compact operators, Compactness of the limit of the sequence of compact operators.

Books recommended

1. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley.
2. H.L. Royden, Real Analysis, MacMillan Publishing Co., Inc., New York, 4th Edition, 1993.
3. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.
4. A. H. Siddiqi, Khalil Ahmad and P. Manchanda, Introduction to Functional Analysis with Applications, Anamaya Publishers, New Delhi-2006.
5. K.C. Rao, Functional Analysis, Narosa Publishing House, Second edition.

MAT-302: Advanced Topology

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Regular, Normal, T_3 and T_4 separation axioms, their characterization and basic properties, Urysohn's lemma and Tietze extension theorem, Regularity and normality of a compact Hausdorff space, Complete regularity, Complete normality, $T_{3\frac{1}{2}}$ and T_5 spaces, their characterization and basic properties.

Section-II

Product topological spaces, Projection mappings, Tychonoff product topology in terms of standard subbases and its characterization, Separation axioms and product spaces, Connectedness, Locally connectedness and compactness of product spaces, Product space as first axiom space, Tychonoff product theorem.

Embedding and Metrization : Embedding lemma and Tychonoff embedding theorem, Metrizable spaces, Urysohn metrization theorem.

Section-III

Nets : Nets in topological spaces, Convergence of nets, Hausdorffness and nets, Subnet and cluster points, Compactness and nets.

Filters : Definition and examples, Collection of all filters on a set as a poset, Methods of generating filters and finer filters, Ultra filter and its characterizations, Ultra filter principle, Image of filter under a function, Limit point and limit of a filter, Continuity in terms of convergence of filters, Hausdorffness and filters, Canonical way of converting nets to filters and vice versa, Stone-Cech compactification.

Section-IV

Covering of a space, Local finiteness, Paracompact spaces, Michaell theorem on characterization of paracompactness, Paracompactness as regular as well as normal space, A. H. Stone theorem, Nagata- Smirnov Metrization theorem.

Books recommended

1. W.J. Pervin, Foundations of General Topology, Academic Press Inc. New York, 1964.
2. K.D. Joshi, Introduction to General Topology, New Age International, 1983.
3. J. L. Kelly, General Topology, Springer Verlag, New York, 2000.
4. J. R. Munkres, Topology, Pearson Education Asia, 2002.
5. Stephen Willard, General Topology, Dover Publications, Inc. Mineola, New York.

6. C. Wayne Patty, Foundations of Topology, Jones and Bartlett Student Edition, 2012.

7. K. Chandrasekhara Rao, Topology, Alpha Science International, 2009.

8. Fred H. Croom, Principles of Topology, Cengage Learning, 2009.

MAT-303: Fluid Dynamics

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Kinematics - Velocity at a point of a fluid. Eulerian and Lagrangian methods. Stream lines, path lines and streak lines. Velocity potential. Irrotational and rotational motions. Vorticity and circulation. Equation of continuity. Boundary surfaces. Acceleration at a point of a fluid. Components of acceleration in cylindrical and spherical polar co-ordinates.

Section-II

Pressure at a point of a moving fluid. Euler equation of motion. Equations of motion in cylindrical and spherical polar co-ordinates.
Bernoulli equation. Impulsive motion. Kelvin circulation theorem. Vorticity equation. Energy equation for incompressible flow. Kinetic energy of irrotational flow. Kelvin minimum energy theorem. Kinetic energy of infinite fluid. Uniqueness theorems.

Section-III

Axially symmetric flows. Liquid streaming part a fixed sphere. Motion of a sphere through a liquid at rest at infinity. Equation of motion of a sphere. Kinetic energy generated by impulsive motion. Motion of two concentric spheres.
Three-dimensional sources, sinks and doublets. Images of sources, sinks and doublets in rigid impermeable infinite plane and in impermeable spherical surface.

Section-IV

Two dimensional motion; Use of cylindrical polar co-ordinates. Stream function. Axisymmetric flow. Stoke stream function. Stoke stream function of basic flows.
Irrotational motion in two-dimensions. Complex velocity potential. Milne-Thomson circle theorem. Two-dimensional sources, sinks, doublets and their images. Blasius theorem.

Books recommended

1. W.H. Besant and A.S. Ramsey, A Treatise on Hydromechanics, Vol.2, CBS Publishers and Distributors, Delhi, 2006.
2. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 2004.
3. O'Neill, M.E. and Chorlton, F., Ideal and Incompressible Fluid Dynamics, Ellis Horwood , 1986.
4. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
5. G.K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.

MAT-304: Mathematical Lab-II

Max. Marks : 50
Credits : 0:0:2

Mathematical problem solving techniques based on paper MAT-101 to MAT-105 will be taught. There will be problems based on 5-6 problem solving techniques from each paper.

Note: Every student will have to maintain practical record of atleast 25 problems solved during practical class work in a file. Examination will be conducted through a question paper set jointly by the external and internal examiners. The question paper will consists of four questions based on problem solving techniques/algorithm. An examinee will be asked to write the solutions of any two in the answer book. Evaluation will be made on the basis of the examinee's performance in written solutions, practical record and viva-voce.

Practical examination will be conducted as per the following distribution of marks:
Writing solutions of problems : 20 marks
Viva Voce : 20 marks
Practical record : 10 marks.

MAT-307: Discrete Mathematics

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Statements: Symbolic Representation and Tautologies, Quantifiers, Predicates and validity, Prepositional Logic.
Semigroups and Monoids- Definitions and examples of semigroups and monoids. Homomorphism of semigroups and monoids. Congruence relation and Quotient semigroups. Subsemigroups and submonoids. Direct products. Basic homomorphism theorem. Pigeonhole principle, principle of inclusion and exclusion, derangements.

Section-II

Lattices - Lattices as partially ordered sets, their properties, Lattices as Algebraic systems. Sub lattices, Direct products and Homomorphism, Some special lattices e.g. Complete, Complemented and Distributive Lattices. Join-irreducible elements, Atoms and Minterms.

Section-III

Boolean Algebras- Boolean Algebras as Lattices. Various Boolean Identities. The Switching Algebra example. Subalgebras, Direct Products and Homomorphism, Boolean forms and their equivalence, Minterm Boolean forms, Sum of Products, Canonical forms, Minimization of Boolean functions, Applications of Boolean Algebra to Switching Theory (using AND, OR and NOT gates). The Karnaugh method.

Section-IV

Finite state Machines and their transition table diagrams, Equivalence of Finite State Machines, Reduced Machines, Homomorphism. Finite automata, Acceptors, Non-deterministic Finite Automata and equivalence of its power to that of deterministic Finite automata, Moore and Mealy Machines.
Grammars and Language: Phrase-Structure Grammars, Rewriting rules, Derivations, Sentential forms, Language generated by a Grammar, Regular, Context-free and Context sensitive grammars and Languages, Regular sets, Regular expressions and the Pumping Lemma, Kleene's theorem.

Books recommended

1. Kenneth H. Rosen, Discrete Mathematics and its Applications, Tata McGraw-Hill, Fourth Edition.
2. Seymour Lipschutz and Marc Lipson, Theory and Problems of Discrete Mathematics, Schaum Outline Series, McGraw-Hill Book Co., New York.
3. John A. Dossey, Albert D. Otto, Lawrence E. Spence and Charles Vanden Eynden, Discrete Mathematics, Pearson, Fifth Edition.

4. J.P. Tremblay and R. Manohar, Discrete mathematical structures with applications to computer science, Tata-McGraw Hill Education Pvt.Ltd.

5. J. Ullman and J. Hopcroft, Introduction to Automata Theory, Languages and Computation, Addison-Wesley.

6. M. K. Das, Discrete Mathematical Structures for Computer Scientists and Engineers, Narosa Publishing House.

7. C. L. Liu and D. P. Mohapatra, Elements of Discrete Mathematics-A Computer Oriented Approach, Tata McGraw-Hill, Fourth Edition.

MAT-308: Fuzzy Set Theory

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Definition of Fuzzy Set, Expanding Concepts of Fuzzy Set, Standard Operations of Fuzzy Set, Fuzzy Complement, Fuzzy Union, Fuzzy Intersection, Other Operations in Fuzzy Set, T- norms and T- conorms. (Chapter 1, 2 of [1])

Section-II

Product Set, Definition of Relation, Characteristics of Relation, Representation Methods of Relations, Operations on Relations, Path and Connectivity in Graph, Fundamental Properties, Equivalence Relation, Compatibility Relation, Pre-order Relation, Order Relation, Definition and Examples of Fuzzy Relation, Fuzzy Matrix, Operations on Fuzzy Relation, Composition of Fuzzy Relation, α-cut of Fuzzy Relation, Projection and Cylindrical Extension, Extension by Relation, Extension Principle, Extension by Fuzzy Relation, Fuzzy distance between Fuzzy Sets. (Chapter 3 of [1])

Section-III

Graph and Fuzzy Graph, Fuzzy Graph and Fuzzy Relation, α-cut of Fuzzy Graph, Fuzzy Network, Reflexive Relation, Symmetric Relation, Transitive Relation, Transitive Closure, Fuzzy Equivalence Relation, Fuzzy Compatibility Relation, Fuzzy Pre-order Relation, Fuzzy Order Relation, Fuzzy Ordinal Relation, Dissimilitude Relation, Fuzzy Morphism, Examples of Fuzzy Morphism. (Chapter 4 of [1])

Section-IV

Interval, Fuzzy Number, Operation of Interval, Operation of α-cut Interval, Examples of Fuzzy Number Operation, Definition of Triangular Fuzzy Number, Operation of Triangular Fuzzy Number, Operation of General Fuzzy Numbers, Approximation of Triangular Fuzzy Number, Operations of Trapezoidal Fuzzy Number, Bell Shape Fuzzy Number. (Chapter 5 of [1]).

Books recommended

1. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.
2. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 1991.
3. John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education, 1999.

MAT-309: Mechanics of Solids

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Cartesian tensors of different orders, Contraction of a tensor, Multiplication and quotient laws for tensors, Substitution and alternate tensors, Symmetric and skew symmetric tensors, Isotropic tensors, Eigenvalues and eigenvectors of a second order symmetric tensor.

Section-II

Analysis of Stress: Stress vector, Normal stress, Shear stress, Stress components, Cauchy equations of equilibrium, Stress tensor of order two, Symmetry of stress tensor, Stress quadric of Cauchy, Principal stresses, Stress invariants, Maximum normal and shear stresses, Mohr diagram.

Section-III

Analysis of Strain: Affine transformations, Infinitesimal affine deformation, Pure deformation, Components of strain tensor and their geometrical meanings, Strain quadric of Cauchy, principal strains, Strain invariants, General infinitesimal deformation, Saint-Venant conditions of compatibility, Finite deformations.

Section-IV

Equations of Elasticity: Generalized Hook's law, Hook's law in an elastic media with one plane of symmetry, Orthotropic and transversely isotropic symmetries, Homogeneous isotropic elastic media, Elastic moduli for an isotropic media, Equilibrium and dynamical equations for an isotropic elastic media, Beltrami - Michell compatibility conditions.

Books recommended

1. I.S. Sokolnikoff, Mathematical theory of Elasticity, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1977.
2. Teodar M. Atanackovic and Ardeshiv Guran, Theory of Elasticity for Scientists and Engineers, Birkhausev, Boston, 2000.
3. Saada, A.S., Elasticity-Theory and applications, Pergamon Press, New York.
4. D.S. Chandersekhariah and L. Debnath, Continuum Mechanics, Academic Press, 1994.
5. Jeffreys, H., Cartesian tensors.
6. A.K. Mal and S.J. Singh, Deformation of Elastic Solids, Prentice Hall, New Jersey, 1991.

MAT-310: Analytical Number Theory

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Distribution of primes, Fermat and Mersenne numbers, Farey series and some results concerning Farey series, Approximation of irrational numbers by rationals, Hurwitz's theorem, Irrationality of e and π.

Section-II

The arithmetic in Z_n, The group U_n, Primitive roots and their existence, the group U_{p^n} (p-odd) and U_{2^n}, The group of quadratic residues Q_n, Quadratic residues for prime power moduli and arbitrary moduli, The algebraic structure of U_n and Q_n.

Section-III

Riemann Zeta Function $\zeta(s)$ and its convergence, Application to prime numbers, $\zeta(s)$ as Euler product, Evaluation of $\zeta(2)$ and $\zeta(2k)$.

Diophantine equations $ax + by = c$, $x^2 + y^2 = z^2$ and $x^4 + y^4 = z^4$, The representation of number by two or four squares, Waring problem, Four square theorem, The numbers g(k) and G(k), Lower bounds for g(k) and G(k).

Section-IV

Arithmetic functions $\phi(n), \tau(n), \sigma(n)$ and $\sigma_k(n)$, U(n), N(n), I(n). Definitions, examples and simple properties, Perfect numbers, Mobius inversion formula, The Mobius function $\mu(n)$, The order and average order of the function $\phi(n), \tau(n)$ and $\sigma(n)$.

Books recommended

1. G. H. Hardy and E. M. Wright, An Introduction to the Theory of Numbers.
2. Gareth A. Jones and J. Mary Jones, Elementary Number Theory, Springer Edition, 1998.
3. D. M. Burton, Elementary Number Theory.
4. N. H. McCoy, The Theory of Numbers, McMillan Company Limited, 1965.
5. I. Niven and H. S. Zuckermann, An Introduction to the Theory of Numbers.

MAT-311: Partial Differential Equations

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Method of separation of variables to solve Boundary Value Problems (B.V.P.) associated with one dimensional heat equation. Steady state temperature in a rectangular plate, Circular disc, Semi-infinite plate. The heat equation in semi-infinite and infinite regions. Solution of three dimensional Laplace equations, Heat Equations, Wave Equations in cartesian, cylindrical and spherical coordinates. Method of separation of variables to solve B.V.P. associated with motion of a vibrating string. Solution of wave equation for semi-infinite and infinite strings.
(Relevant topics from the book by O'Neil)

Section-II

Partial differential equations: Examples of PDE classification. Transport equation - Initial value problem. Non-homogeneous equations.
Laplace equation - Fundamental solution, Mean value formula, Properties of harmonic functions, Green function.

Section-III

Heat Equation - Fundamental solution, Mean value formula, Properties of solutions, Energy methods.
Wave Equation - Solution by spherical means, Non-homogeneous equations, Energy methods.

Section-IV

Non-linear first order PDE - Complete integrals, Envelopes, Characteristics, Hamilton Jacobi equations.
Calculus of variations, Hamilton ODE, Legendre transform, Hopf-Lax formula, Weak solutions, Uniqueness.

Books recommended

1. I.N. Sneddon, Elements of Partial Differential Equations, McGraw Hill, New York.
2. Peter V. O'Neil, Advanced Engineering Mathematics, ITP.
3. L.C. Evans, Partial Differential Equations: (Graduate Studies in Mathematics) 2nd Edition, American Mathematical Society, 2010.
4. H.F. Weinberger, A First Course in Partial Differential Equations, John Wiley and Sons, 1965.
5. M.D. Raisinghania, Advanced Differential equations, S. Chand and Co.

MAT-312: Difference Equations

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Difference Calculus: Introduction, The Difference Operator, Summation, Generating functions and Approximate Summation.

Section-II

Linear Difference Equations: First Order Equations, General Results for Linear Equations, Solving Linear Equations, Applications, Equations with Variable Coefficients, Nonlinear Equations that can be Linearized, The z-Transform.

Section-III

Stability Theory: Initial Value Problems for Linear Systems, Stability of Linear Systems, Phase Plane Analysis for Linear Systems, Fundamental Matrices and Floquet Theory, Stability of Nonlinear Systems, Chaotic Behavior.

Section-IV

Asymptotic Methods: Introduction, Asymptotic Analysis of Sums, Linear Equations, Nonlinear Equations.

Books recommended

1. Walter Kelley and Allan Peterson, Difference Equations, An Introduction with Applications, Academic Press
2. Calvin Ahlbrant and Allan Peterson, Discrete Hamiltonian Systems, Difference Equations, Continued Fractions and Riccati Equations, Kluwer (1996).
3. Saber Elaydi, An Introduction to Difference Equations, Springer

MAT-313: Mathematical Modeling

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Introduction and the technique of mathematical modeling, Classification and characteristics of mathematical models. Mathematical modeling through algebra, Finding the radius of the earth, Motion of planets, Motions of satellites. Linear and Non-linear growth and decay models, Population growth models. Effects of Immigration and Emigration on Population size, Decrease of temperature, Diffusion, Change of price of a commodity, Logistic law of population growth. A simple compartment model. Diffusion of glucose or a Medicine in the blood stream.

Section-II

Mathematical modelling of epidemics, A simple epidemics model, A susceptible-infected-susceptible (SIS) model, SIS model with constant number of carriers, Simple epidemic model with carriers, Model with removal, Model with removal and immigration.
Mathematical modelling in economics, Domar macro model, Domar first debt model, Domar second debt model, Samuelson investment model, Stability of market equilibrium. Mathematical modelling in medicine, Arms race and battles: A model for diabetes mellitus, Richardson model for arms race, Lamechester combat model.

Section-III

Mathematical modelling through partial differential equations: Mass-balance Equations, Momentum-balance Equations, Variational principles, Probability generating function, Modelling for traffic on a highway.

Section-IV

Stochastic models of population growth, Need for stochastic models, Linear birth-death-immigration-emigration processes, Linear birth-death process, Linear birth-death-immigration process, Linear birth-death-emigration process, Non-linear birth-death process.

Books recommended

1. J.N. Kapur, Mathematical Modeling, New Age International Limited.
2. J.N. Kapur, Mathematical Models in Biology and Medicine, Affiliated East-West Press (P) Ltd.
3. D.N. Burghes and A.D. Wood, Mathematical Models in the Social, Management and Life Sciences, John Wiley and Sons.
4. J.G. Andrews and R.R Mclone, Mathematical Modeling, Butterworths (Pub.) Inc.

MAT-314: Computational Fluid Dynamics

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Basic equations of Fluid dynamics. Analytic aspects of partial differential equations- classification, Boundary conditions, Maximum principles, Boundary layer theory.
Finite difference and Finite volume discretizations. Vertex-centred discretization. Cell-centred discretization. Upwind discretization. Nonuniform grids in one dimension.

Section-II

Finite volume discretization of the stationary convection-diffusion equation in one dimension. Schemes of positive types. Defect correction. Non-stationary convection-diffusion equation. Stability definitions. The discrete maximum principle.
Incompressible Navier-Stokes equations. Boundary conditions. Spatial discretization on collocated and on staggered grids. Temporal discretization on staggered grid and on collocated grid.

Section-III

Iterative methods. Stationary methods. Krylov subspace methods. Multigrade methods. Fast Poisson solvers.
Iterative methods for incompressible Navier-Stokes equations.
Shallow-water equations One and two dimensional cases. Godunov order barrier theorem.

Section-IV

Linear schemes. Scalar conservation laws. Euler equation in one space dimension analytic aspects. Approximate Riemann solver of Roe.
Osher scheme. Flux splitting scheme. Numerical stability. Jameson Schmidt Turkel scheme. Higher order schemes.

Books recommended

1. P. Wesseling, Principles of Computational Fluid Dynamics, Springer-Verlag, 2000.
2. J.F. Wendt, J.D. Anderson, G. Degrez and E. Dick, Computational Fluid Dynamics : An Introduction, Springer-Verlag, 1996.
3. J.D. Anderson, Computational Fluid Dynamics : The basics with applications, McGraw-Hill, 1995.
4. K. Muralidher, Computational Fluid Flow and Heat Transfer, Narosa Pub. House.
5. T.J. Chung, Computational Fluid Dynamics, Cambridge Uni. Press.
6. J.N. Reddy, An introduction to the Finite Element Methods, McGraw Hill International Edition, 1985.

Department of Mathematics
(Open Elective Course for students of other Departments)
Semester-III

MAT-315: Basics of Vedic Mathematics

Time : 3 hours | **Theory Marks : 80**
Internal Marks : 20
Credits : 3:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions from each unit and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions without any internal choice covering the entire syllabus.

Unit-I

- Introduction to Vedic Mathematics
- Importance of Vedic Mathematics
- Number system and its applications in Vedic Mathematics
- Multiplication of any number by numbers containing digit 1 only
- Multiplication of any number by numbers containing digit 9 only
- Multiplication using Sutra-Urdhvatiryagbhyam

Unit-II

- Multiplication using base and sub-base method
- Multiplication using Ekadhikena Sutra
- Sum and Difference of Products
- Square using Nikhilam Sutra
- Square using Duplex Method
- Addition and subtraction of squared and products numbers

Unit-III

- Cube using Nikhilam and Anurupyena Sutra
- Division using Dhwajank Method
- Meru-prastar and their applications
- Square root and cube root
- Algebraic Multiplication

Unit-IV

- Addition and subtraction of algebraic products
- Square and square root of algebraic expressions
- Simultaneous simple equations
- Miscellaneous Simple equations
- Auxiliary fractions
- Triplets

Reference Books

1. Bharti Krishan Tirath: Vedic Mathematics, Motilal Banarsidas New Delhi, 2001.

2. Dr.Vyawahare-Chouthaiwale-Borgaonkar: Introduction to Vedic Mathematics, Swadhaya mandal, Kille pardi, Gujarat. 2003.

3. Chouthaiwale-Kolluru: Enjoy Vedic Mathematics, Sri Sri Publications Trust, Banglore, 2010.

4. N. K. Jain, Choudhary: Vedic and Jain Mathematics, Vishwa Punar Nirman, Talangkhedi, Nagpur.

5. V. G. Unkalkar: Magic world of Mathematics, Vandana Publishers Banglore, 2008.

6. V. G. Unkalkar: Excel with Vedic Mathematics, Vandana Publishers Banglore, 2009.

7. V. G. Heroor, The History mathematics and Mathematicians of India, Vidya Bharti, Banglore, 2006.

8. V. G. Heroor, Jyopati, Rajasthan Sanskrit University, Jaipur, 2007.

Indira Gandhi University, Meerpur (Rewari)

Scheme of Examination and Syllabi

for

M.Sc.(Mathematics) 4th Semester

w.e.f. session 2020-21

as per

Choice Based Credit System (CBCS)

Indira Gandhi University, Meerpur (Rewari)
Scheme of Examination
M.Sc. Mathematics
Under Choice Based Credit System
w.e.f. Session 2020-21

Semester-IV

Core Courses

Course Code	Title of the Course	Theory Marks	Internal Marks	Practical Marks	Credits L:T:P	Contact hrs per week	Total Credits
MAT-401	Inner Product Spaces and Measure Theory	80	20	-	4:0:0	4	4
MAT-402	Classical Mechanics	80	20	-	4:0:0	4	4
MAT-403	Viscous Fluid Dynamics	80	20	-	4:0:0	4	4
MAT-404	Computing Lab-II (MATLAB)	-	-	50	0:0:2	4	2
MAT-405	Seminar	-	-	25	-	-	1
MAT-406	Self Study Paper	-	-	25	-	-	1

Discipline Centric Elective Courses (Any two)

Course Code	Title of the Course	Theory Marks	Internal Marks	Credits L:T:P	Contact hrs per week	Total Credits
MAT-407	Advanced Complex Analysis	80	20	4:0:0	4	4
MAT-408	Graph Theory	80	20	4:0:0	4	4
MAT-409	Applied Solid Mechanics	80	20	4:0:0	4	4
MAT-410	Bio Mechanics	80	20	4:0:0	4	4
MAT-411	Algebraic Number Theory	80	20	4:0:0	4	4
MAT-412	Algebraic Coding Theory	80	20	4:0:0	4	4
MAT-413	Bio-Fluid Dynamics	80	20	4:0:0	4	4
MAT-414	Fractional Calculus	80	20	4:0:0	4	4

Total Credits : 24
Total Contact Hours per Week : 24
Max Marks : 600

Note: Optional papers can be offered subject to the availability of requisite resources/faculty.

General Guidelines

1. Seminar

In each semester, there will be a paper on seminar presentation of 25 marks with 01 credit. In this paper, the student will be required to present a seminar of about 15-20 minutes on the theme/topic such as review of research papers/articles published in National/International Journals in his /her area of interest. The topic will be selected by the student in consultation with the teacher alloted to him/her by the department.

An internal committee of two teachers constituted by the Chairperson of the department for each student will evaluate the seminar presentation. The evaluation (Internal evaluation only) will be based on the presentation of student, depth of subject matter and answer to questions. There will be a Coordinator to be nominated by the Chairperson of the Department among the teachers of the Department.

For seminar, the topics should be chosen in the following manner:

1st Semester	Any topic (not related to the syllabi)
2nd Semester	Any Basic Research Paper/Article
3rd Semester	Any National Level Research Paper/Article
4th Semester	Any Foreign Research Paper/Article

2. Self Study Paper

In each semester, there will be a self study paper of 25 marks with 01 credit. The objective of this paper is to create habits of reading books and to develop writing skills in a manner of creativity and originality. The students will select a topic of their own interest in the given area in consulation with their teachers/incharge/mentors. After selecting a suitable title for the paper, the students will be required to prepare a hand written report of about 6-10 pages in his/her own handwritng. The students will be required to submit the report after getting it checked by the concerned teacher and will be asked to re-submit the report after making the required corrections(if any) before the commencment of the examinations of that semester. The structure of the paper will include the following:

- Introduction
- Main Body
- Conclusion

The thoughts presented in the paper must be original work of the students.

The paper will be evaluated by the panel (one external and one internal examiner) to be appointed by the Chairperson of Department from the prescribed panel of the University.

The evaluation of Self Study paper will be done as given below:

- Evaluation of the paper : 15 marks
- Viva-Voce on the paper : 10 marks
- Total : 25 marks

MAT-401: Inner Product Spaces and Measure Theory

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Hilbert Spaces: Inner product spaces, Hilbert spaces, Schwarz's inequality, Hilbert space as normed linear space, Convex sets in Hilbert spaces, Projection theorem.

Section-II

Orthonormal sets, Separability, Total Orthonormal sets, Bessel's inequality, Parseval's identity.

Conjugate of a Hilbert space, Riesz representation theorem in Hilbert spaces, Adjoint of an operator on a Hilbert space, Reflexivity of Hilbert space, Self-adjoint operators, Positive operators, Product of Positive Operators.

Section-III

Projection operators, Product of Projections, Sum and Difference of Projections, Normal and unitary operators, Projections on Hilbert space, Spectral theorem on finite dimensional space.
Measure space, Generalized Fatou's lemma, Measure and outer measure, Extension of a measure, Caratheodory extension theorem.

Section-IV

Signed measure, Hahn decomposition theorem, Jordan decomposition theorem, Mutually signed measure, Radon-Nikodym theorem, Lebesgue decomposition, Lebesgue-Stieltjes integral, Product measures, Fubini's theorem, Baire sets, Baire measure, Continuous functions with compact support.

Books recommended

1. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963
2. H.L. Royden, Real Analysis, MacMillan Publishing Co., Inc., New York, 4th Edition, 1993.
3. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley (1978).
4. S.K. Berberian, Measure and Integration, Chelsea Publishing Company, New York, 1965.
5. K.C. Rao, Functional Analysis, Narosa Publishing House, Second edition, 2006.

MAT-402: Classical Mechanics

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Moments and products of inertia, The theorems of parallel and perpendicular axes, Angular momentum of a rigid body about a fixed point and about fixed axes, Principal axes and principal moments of inertia of a rigid body, Kinetic energy of a rigid body rotating about a fixed point, Momental ellipsoid and equimomental systems, Coplanar mass distributions, General motion of a rigid body. (Relevant topics from the book of Chorlton).

Section-II

Free and constrained systems, Constraints and their classification, Holonomic and non-holonomic systems, Scleronomic and Rheonomic systems, Possible and Virtual Displacements, Possible velocities and possible accelerations, Ideal constraints, The General equation of dynamics, Lagrange's equations of the first kind. The Principle of Virtual Displacements, D' Alembert's Principle.

Independent coordinates and Generalized forces, Lagrange's equations of the second kind in independent coordinates, Generalized velocities and accelerations, Kinetic energy as a function of generalized velocities, Uniqueness of solution, Theorem on Variation of total energy, Potential, Gyroscopic and Dissipative Forces.

Section-III

Lagrange's equations for Potential Forces, The Generalized Potential, Lagrangian and Hamiltonian variables, Donkin's theorem, Hamilton canonical equations, Routh variables and Routh function, Routh's equations, Cyclic or Ignorable coordinates, Poisson Bracket and their simple properties, Poisson identity, Jacobi-Poisson theorem.

Hamilton's principle, Poincare-Carton Integral Invariant, Generalized Conservative Systems, Whittaker's equations, Jacobi's equations, Lagrangian action and the principle of least action. The Universal Integral Invariant of Poincare, Lee Hwa-Chung's Theorem (Statement only).

Section-IV

Canonical transformations, Necessary and sufficient condition for a transformation to be canonical, Univalent canonical transformations, Free canonical transformations, Hamilton-Jacobi equation, Jacobi's theorem, Method of separation of variables in HJ equation.

The Lagrange Brackets, Necessary and sufficient conditions for the canonical character of a transformation in terms of Lagrange Brackets, The Simplicial Nature of the Jacobian Matrix of a canonical transformation, Conditions of canonicity of a transformation in terms of Poisson Brackets, Invariance of the Poisson Brackets in a canonical transformation.

Books recommended

1. F. Chorlton, Textbook of Dynamics, CBS Publishers, New Delhi.

2. F. Gantmacher, Lectures in Analytical Mechanics, MIR Publishers, Moscow, 1975.

3. N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw- Hill, New Delhi, 1991.

4. P.V. Panat, Classical Mechanics, Narosa Publishing House, New Delhi, 2005.

5. Louis N. Hand and Janet D. Finch, Analytical Mechanics, CUP, 1998.

6. K. Sankra Rao, Classical Mechanics, Prentice Hall of India, 2005.

7. M.R. Speigal, Theoretical Mechanics, Schaum Outline Series.

MAT-403: Viscous Fluid Dynamics

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Vorticity in two dimensions, Circular and rectilinear vortices, Vortex doublet, Images, Motion due to vortices, Single and double infinite rows of vortices. Karman vortex street. Wave motion in a Gas. Speed of sound in a gas. Equation of motion of a Gas. Subsonic, sonic and supersonic flows. Isentropic gas flow, Flow through a nozzle.

Section-II

Stress components in a real fluid. Relation between Cartesian components of stress. Translational motion of fluid element. Rates of strain. Transformation of rates of strains. Relation between stresses and rates of strain. The co-efficient of viscosity and laminar flow. Newtonian and non-Newtonian fluids. Navier-Stoke equations of motion. Equations of motion in cylindrical and spherical polar co-ordinates. Equation of energy. Diffusion of vorticity. Energy dissipation due to viscosity. Equation of state..

Section-III

Plane Poiseuille and Couette flows between two parallel plates. Theory of lubrication. Hagen Poiseuille flow. Steady flow between co-axial circular cylinders and concentric rotating cylinders. Flow through tubes of uniform elliptic and equilateral triangular cross-section. Unsteady flow over a flat plate. Steady flow past a fixed sphere. Flow in convergent and divergent chennals.

Section-IV

Dynamical similarity. Inspection analysis. Non-dimensional numbers. Dimensional analysis. Buckingham p-theorem and its application. Physical importance of non-dimensional parameters. Prandtl boundary layer. Boundary layer equation in two-dimensions. The boundary layer on a flat plate (Blasius solution). Characteristic boundary layer parameters. Karman integral conditions. Karman-Pohlhausen method.

Books recommended

1. W.H. Besaint and A.S. Ramasey, A Treatise on Hydromechanics, Part II, CBS Publishers, Delhi, 1988.
2. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985
3. O'Neill, M.E. and Chorlton, F., Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986.
4. O'Neill, M.E. and Chorlton, F., Viscous and Compressible Fluid Dynamics, Ellis Horwood Limited, 1989.

5. S.W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi, 1976.

6. H. Schlichting, Boundary-Layer Theory, McGraw Hill Book Company, New York, 1979.

7. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.

8. G.K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.

MAT-404: Computing Lab-II (MATLAB)

Time : 4 hours **Max. Marks : 50**

Credits : 0:0:2

Note: **(A)** Each candidate will be provided a question paper of four questions and will be required to attempt two questions. The candidate will first the program in MATLAB of the questions in the answer-book and then run the same on the computer, and then finally add the print-outs of these programs in the answer-book. This work will consist of 30 marks, 15 marks for each question.

(B) The practical file of each student will be checked and Viva-Voce examination based upon the practical file and the theory will be jointly conducted by external and internal examiners. This part of the practical examination shall be of 20 marks.

MAT-407: Advanced Complex Analysis

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Integral Functions, Factorization of an integral function, Weierstrass primary factors, Weierstrass factorization theorem, Gamma function and its properties, Stirling formula, Integral version of gamma function, Riemann Zeta function, Riemann functional equation, Mittag-Leffler theorem, Runge theorem(Statement only).

Section-II

Analytic Continuation, Natural Boundary, Uniqueness of direct analytic continuation, Uniqueness of analytic continuation along a curve, Power series method of analytic continuation, Schwarz Reflection principle, Germ of an analytic function. Monodromy theorem and its consequences, Harmonic functions on a disk, Poisson kernel, The Dirichlet problem for a unit disc.

Section-III

Harnack inequality, Harnack theorem, Dirichlet region, Green function, Canonical product, Jensen formula, Poisson-Jensen formula, Hadamard three circles theorem, Growth and order of an entire function, An estimate of number of zeros, Exponent of convergence, Borel theorem, Hadamard factorization theorem.

Section-IV

The range of an analytic function, Bloch theorem, Schottky theorem, Little Picard theorem, Montel Caratheodory theorem, Great Picard theorem, Univalent functions, Bieberbach conjecture (Statement only) and the "1/4 theorem" .

Books recommended

1. H. A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
2. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 2011.
3. J. B. Conway, Functions of one complex variable, Springer-Verlag, International Student Edition, Narosa Publishing House, 2002.
4. Liang-shin Hann and Bernand E., Classical Complex Analysis, Jones and Bartlett Publishers International, London, 1996.
5. E. T. Copson, An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, London.
6. E. C. Titchmarsh, The Theory of Functions, Oxford University Press, London.

7. Mark J. Ablowitz and A.S. Fokas, Complex Variables: Introduction and Applications, Cambridge University Press, South Asian Edition, 1998.

8. Ruel V. Churchill and James Ward Brown, Complex Variables and Applications, McGraw-Hill Publishing Company.

9. H.S. Kasana, Complex Variable Theory and Applications, PHI Learning Private Ltd, 2011.

MAT-408: Graph Theory

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Definition and types of graphs, Walks, Paths and Circuits, Connected and Disconnected graphs, Applications of graphs, operations on Graphs, Graph Representation, Isomorphism of Graphs.

Section-II

Eulerian and Hamiltonian paths, Shortest Path in a Weighted Graph, The Travelling Sales person Problem, Planar Graphs, Detection of Planarity and Kuratowski Theorem, Graph Colouring.

Section-III

Directed Graphs, Trees, Tree Terminology, Rooted Labeled Trees, Prefix Code, Binary Search Tree, Tree Traversal.

Section-IV

Spanning Trees and Cut Sets, Minimum Spanning Trees, Kruskal Algorithm, Prim Algorithm, Decision Trees, Sorting Methods.

Books recommended

1. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, PHI Pvt. Ltd, 2004.
2. F. Harary: Graph Theory, Addition Wesley, 1969.
3. G. Chartrand and P. Zhang. Introduction to Graph Theory, Tata McGraw-Hill, 2006.
4. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill, Fourth Edition, 1999.
5. Seymour Lipschutz and Marc Lipson, Theory and Problems of Discrete Mathematics, Schaum Outline Series, McGraw-Hill Book Co, New York, 2007.
6. John A. Dossey, Otto, Spence and Vanden K. Eynden, Discrete Mathematics, Pearson, Fifth Edition, 2005.
7. C. L. Liu and D.P. Mohapatra, Elements of Discrete Mathematics- A Computer Oriented Approach, Tata McGraw-Hill, Fourth Edition.

MAT-409: Applied Solid Mechanics

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Two dimensional problems: Plane strain deformation, State of plane stress, Generalized plane stress, Airy stress function for plane strain problems, Solutions of a two-dimensional biharmonic equation using Fourier transform as well as in terms of two analytic functions, Expressions for stresses and displacements in terms of complex potentials, Deformation of a thick-walled elastic tube under external and internal pressures.

Section-II

Torsion of Beams: Torsion of a circular cylindrical beam, Torsional rigidity, Torsion and stress functions, Lines of shearing stress, Torsion of a beam of arbitrary cross-section and its special cases for circular, elliptic and equilateral triangular cross-sections, Circular groves in an circular beam.
Extension of Beams: Extension of beams by longitudinal forces, Beams stretched by its own weight.

Section-III

Bending of Beams: Bending of beams by terminal couples, Bending of a beam by transverse load at the centroid of the end section along a principal axis.
Variational Methods: One-dimensional Ritz method, Two - dimensional Ritz method, Galerkin method, Application to torsion of beams.
(Relevant topics from the Sokolnikof book).

Section-IV

Waves: Simple harmonic progressive waves, Plane waves, Progressive type solutions in cartesian coordinates, Stationary type solutions in Cartesian coordinates.
Elastic Waves: Propagation of waves in an unbounded elastic isotropic media, P-waves, S - waves, Wave propagation in two-dimensions, P-SV waves and SH waves.

Books recommended

1. I. S. Sokolnikof, Mathematical theory of Elasticity, Tata McGraw Hill Publishing company Ltd. New Delhi, 1977.
2. Teodar M. Atanackovic and Ardeshiv Guran, Theory of Elasticity for Scientists and Engineers, Birkhausev, Boston, 2000.
3. A. K. Mal and S.J. Singh, Deformation of Elastic Solids, Prentice Hall, New Jersey, 1991.
4. C. A. Coluson, Waves.
5. A. S. Saada, Elasticity-Theory and Applications, Pergamon Press, New York, 1973.
6. D. S. Chandersekharian and L.Debnath, Continuum Mechanics, Academic Press.

MAT-410: Bio-Mechanics

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Newton equations of motion, Mathematical modeling, Continuum approach, Segmental movement and vibrations, Lagrange equations, Normal modes of vibration, Decoupling of equations of motion. Flow around an airfoil, Flow around bluff bodies, Steady state aeroelastic problems, Transient fluid dynamics forces due to unsteady motion, Flutter.

Section-II

Kutta-Joukowski theorem, Circulation and vorticity in the wake, Vortex system associated with a finite wing in nonsteady motion, Thin wing in steady flow.
Blood flow in heart, lungs, arteries, and veins, Field equations and boundary conditions, Pulsatile flow in arteries, Progressive waves superposed on a steady flow, Reflection and transmission of waves at junctions.

Section-III

Velocity profile of a steady flow in a tube, Steady laminar flow in an elastic tube, Velocity profile of Pulsatile flow, The Reynolds number, Stokes number, and Womersley number, Systematic blood pressure, Flow in collapsible tubes.
Micro- and macro-circulation Rheological properties of blood, Pulmonary capillary blood flow, Respiratory gas flow, Intraction between convection and diffusion, Dynamics of the ventilation system.

Section-IV

Laws of thermodynamics, Gibbs and Gibbs Duhem equations, Chemical potential, Entropy in a system with heat and mass transfer, Diffusion, Filtration, and fluid movement in interstitial space in thermodynamic view, Diffusion from molecular point of view.
Mass transport in capillaries, Tissues, Interstitial space, Lymphatics, Indicator dilution method, and peristalsis, Tracer motion in a model of pulmonary micro-circulation.

Books recommended

1. Y.C. Fung, Biomechanics: Motion, Flow, Stress and Growth, Springer-Verlag, New York Inc., 1990.

MAT-411: Algebraic Number Theory

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Algebraic Number and Integers : Gaussian integers and its properties, Primes and fundamental theorem in the ring of Gaussian integers, Integers and fundamental theorem in $Q(\omega)$ where $\omega^3 = 1$, Algebraic fields, Primitive polynomials, The general quadratic field $Q(\sqrt{m})$, Units of $Q(\sqrt{2})$, Fields in which fundamental theorem is false, Real and complex Euclidean fields, Fermat theorem in the ring of Gaussian integers, Primes of $Q(\sqrt{2})$ and $Q(\sqrt{5})$.

Section-II

Countability of set of algebraic numbers, Liouville theorem and generalizations, Transcendental numbers, Algebraic number fields, Liouville theorem of primitive elements, Ring of algebraic integers, Theorem of primitive elements.

Section-III

Norm and trace of an algebraic number, Non degeneracy of bilinear pairing, Existence of an integral basis, Discriminant of an algebraic number field, Ideals in the ring of algebraic integers, Explicit construction of integral basis, Sign of the discriminant, Cyclotomic fields, Calculation for quadratic and cubic cases.

Section-IV

Integral closure, Noetherian ring, Characterizing Dedekind domains, Fractional ideals and unique factorization, G.C.D. and L.C.M. of ideals, Chinese remainder theorem, Dedekind theorem, Ramified and unramified extensions, Different of an algebraic number field, Factorization in the ring of algebraic integers.

Books recommended

1. Esmonde and M Ram Murty, Problems in Algebraic Number Theory, GTM Vol. 190, Springer Verlag, 1999.
2. G.H. Hardy and E.M. Wright, An Introduction to the Theory of Numbers
3. W.J. Leveque, Topics in Number Theory Vols. I, III Addition Wesley.
4. H. Pollard, The Theory of Algebraic Number, Carus Monogrpah No. 9, Mathematical Association of America.
5. P. Riebenboim, Algebraic Numbers Wiley Inter-science.
6. E. Weiss, Algebraic Number Theory, McGraw Hill.

MAT-412: Algebraic Coding Theory

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

The communication channel, The coding problem, Types of codes, Block codes, Types of codes such as repetition codes, Parity check codes and their error-detection and correction capabilities. Hamming metric, Relationship of error detection/correction with hamming distance, Maximum likelihood decoding procedure, Decoding by syndrome decoding and Coset leaders, Standard array.

Section-II

Linear codes (Binary and non binary), Minimum distance, Dimension, Modular representation of linear codes, Description of linear codes by matrices, Polynomial codes, Generator and parity check polynomials and matrices.

Section-III

Dual codes, Self duality, Weight distribution of dual of binary linear codes, Macwilliam identity (binary case) extending, Expurgating and augmenting a code, Lee metric, Convolutional codes, Description using matrices and polynomials, Encoding using (4,3,2) encoder.

Section-IV

Hamming codes (Binary and non-binary) and their properties, Perfect and quasi-perfect codes. Golay codes as perfect codes, Bounds on minimum distance for block codes, Plotkin bound, Hamming sphere.

Books recommended

1. Raymond Hill, A First Course in Coding Theory, Oxford University Press, 1986.
2. Man Young Rhee, Error Correcting Coding Theory, McGraw Hill Inc., 1989.
3. W. W. Peterson and E.J. Weldon, Jr., Error-Correcting Codes. M.I.T. Press, Cambridge Massachuetts, 1972.
4. E. R. Berlekamp, Algebraic Coding Theory, McGraw Hill Inc., 1968.
5. F. J. Macwilliams and N.J.A. Sloane, Theory of Error Correcting Codes, North-Holand Publishing Company.
6. J. H. Van Lint, Introduction to Coding Theory, Graduate Texts in Mathematics, 86, Springer, 1998.
7. L. R. Vermani, Elements of Algebraic Coding Theory, Chapman and Hall, 1996.

MAT-413: Bio-Fluid Dynamics

Time : 3 hours **Max. Marks : 80**
Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Basic concepts of fluid dynamics. Viscosity. Reynold transport theorem, Rates of change of material integrals, Continuity equation, Navier-Stokes equations of motion, Simplification of basic equations. Reynolds number of flows.
The cardiovascular system. The circulatory system. Systemic and pulmonary circulations. The circulation in the heart. Diseases related to circulation.

Section-II

Blood composition. Structure of blood. Viscosity of blood. Yield stress of blood. Blood vessel structure. Diseases related to obstruction of blood flow.
Flow in pipes and ducts. Developing and fully developed flow. Special characteristics of blood flow. Poiseuille flow and its consequence. Applications of Poiseuille law for the study of blood flow.

Section-III

Pulsatile flow in circular rigid tube and its quantitative aspects. The pulse wave. Mones-Korteweg expression for wave velocity in an inviscid fluid-filled elastic cylindrical tube and its applications in the cardiovascular system. Wave propagation accounting for viscosity and its application to cardiac output determination. Blood flow through artery with mild stenosis, Expressions for pressure drop across the stenosis and across the whole length of artery. Shear stress on stenosis surface.

Section-IV

Non-Newtonian fluids and their classification. Laminar flow of non-Newtonian fluids.
Power-law model, Herschel-Bulkley model, Casson model. Flow in the renal tubule. Solutions when radial velocity at the wall decreases (i) linearly with z (ii) exponentially with z. Peristaltic flows. Peristaltic motion in a channel, Characteristic dimensionless parameters. Long- wavelength analysis.

Books recommended

1. Jagan N. Mazumdar; Biofluid Mechanics, World Scientific Pub.
2. J. N. Kapur; Mathematical Models in Biology and Medicine, Affiliated East-West Press Pvt. Ltd.
3. T. J. Pedley; The Fluid Mechanics of Large Blood Vessels, Cambridge Uni. Press, 1980.
4. M. Stanley; Transport Phenomenon in Cardiovascular System, 1972.
5. O'Neill, M. E. and Chorlton, F., Viscous and Compressible Fluid Dynamics, Ellis Horwood Limited, 1989.
6. J. L. Bansal, Viscous Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 2000.

MAT-414: Fractional Calculus

Time : 3 hours **Max. Marks : 80**

Credits : 4:0:0

Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Gamma Function: Definition of the Gamma function, Some properties of the Gamma function, Limit Representation of the Gamma function, Beta Function, Contour Integral Representation, Contour Integral Representation of $\frac{1}{\Gamma(z)}$

Mittag-Leffler Function: Definition and Relation to some other functions, The Laplace transformation of the Mittag-Leffler Function in two parameters, Derivative of the Mittag-Leffler Function, Differential Equations for the Mittag-Leffler Function, Summation Formulas, Integration of the Mittag-Leffler function.

Section-II

The name of the Game, Grunwald Letnikov Fractional derivatives: Unification of Integer-order Derivatives and integrals, Integrals of Arbitrary Order, Derivatives of Arbitrary order, Fractional Derivative of , Composition with integer-order Derivatives, Composition with Fractional Derivatives Riemann Liouville Fractional Derivatives: Unification of integral-order Derivatives and Integrals, Integrals of Arbitrary Order, Derivatives of Arbitrary Order, Fractional Derivative of $(t-a)^{\beta}$, Composition with Integer-Order Derivatives, Composition with Fractional Derivatives, Link of the Grtunwald-letnikov Approach,

Section-III

Some Other Approaches: Caputos Fractional Derivative, Generalized Functions Approach, Sequential Fractional Derivatives, Left and Right Fractional Derivatives.

Properties of fractional Derivatives: Linearity, The Leibniz Rule for Fractional Derivatives, Fractional Derivative of a Composite Function, Riemann Liouville fractional Differentiation of an Integral depending on a Parameter, Behaviour near the Lower terminal, Behaviour far from the Lower terminal.

Laplace transforms of Fractional Derivatives: Basic Facts on the Laplace transform, Laplace Transform of the Riemann-Liouville Fractional Derivatives, Laplace Transform of the Caputo Derivative, Laplace Transform of the Grunwald-Letnikov Fractional Derivative, Laplace transform of the Miller Ross Sequential Fractional Derivative

Section-IV

Fourier transforms of Fractional Derivatives: Basic Facts on the Fourier transform, Fourier Transform of Fractional Integrals, Fourier Transform of Fractional Derivatives.

Linear Fractional Differential Equations, Fractional Differential equation of the General Form, Existence and Uniqueness theorem as a Method of Solution, Dependence of a Solution on Initial Conditions.

Standard Fractional Differential Equations: Ordinary Linear Fractional Differential Equations, Partial Linear Fractional Differential Equations.

Sequential Fractional Differential Equations:Ordinary Linear Fractional Differential Equations,Partial Linear Fractional Differential Equations.

Books recommended

1. K.S. Miller and B. Rose, An Introduction to the Fractional Calculus and Fractional Differential Equations, John Wiley & sons Inc., New York, 1993.

2. Igor Podlubny, Fractional Differential Equations, Academic Press.

3. OLDHAM, Keith B., SPNIER, Jerome. The Fractional Calculus. London: Academic Press c1974. 225p.

4. J. Hadamard. Lectures on Cauchys problem in Linear Partial Fractional Equations. Yale Univ. press, New haven, 1923.

5. A. Carpinteri and F. Mainardi (eds.), Fractals and Fractional Calculus in Continuum Mechanics, Springer verlag, Vienna-New York, 1997.