Scheme of Examination of M.Sc. Mathematics
Programme Code: MAT2
Semester- I
(w.e.f. Session 2016-17)

Course Code	Title of the Course	Theory Marks	Internal marks	Practical Marks	Credits (L:T:P)
		Core			
16MAT21C1	Abstract Algebra	80	20	--	4:1:0
16MAT21C2	Mathematical Analysis	80	20	--	4:1:0
16MAT21C3	Ordinary Differential Equations	80	20	--	4:1:0
16MAT21C4	Complex Analysis	80	20	--	4:1:0
16 MAT21C5	Mathematical Statistics	80	20	--	4:1:0

Total Credits : 25

Note 1 : The Criteria for awarding internal assessment of 20 marks shall be as under:

A) Class test : 10 marks.
B) Assignment & Presentation : 5 marks
C) Attendance : 5 marks
Less than 65% : *0 marks*
Upto 70% : *2 marks*
Upto 75% : *3 marks*
Upto 80% : *4 marks*
Above 80% : *5 marks*

Note 2 : The syllabus of each course will be divided into **four** Sections of **two** questions each. The question paper of each course 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 contain **eight** short answer type questions without any internal choice covering the entire syllabus.

16MAT21C1: Abstract Algebra

Time: 03 Hours
Max Marks : 80 ***Credits : 4:1:0***

Course Outcomes

Students would be able to:

CO1 Apply group theoretic reasoning to group actions.

CO2 Learn properties and analysis of solvable & nilpotent groups, Noetherian & Artinian modules and rings.

CO3 Apply Sylow's theorems to describe the structure of some finite groups and use the concepts of isomorphism and homomorphism for groups and rings.

CO4 Use various canonical types of groups and rings- cyclic groups and groups of permutations, polynomial rings and modular rings.

CO5 Analyze and illustrate examples of composition series, normal series, subnormal series.

Section - I

Conjugates and centralizers in S_n, p-groups, Group actions, Counting orbits. Sylow subgroups, Sylow theorems, Applications of Sylow theorems, Description of group 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, Equivalent conditions for a finite group to be nilpotent, Upperandlower central series. Composition series, Zassenhaus lemma, Jordan-Holder theorem.

Section - III

Modules, Cyclic modules, Simple and semi-simple modules, Schur lemma, Free modules, Torsion modules, Torsion free modules, Torsion part of a module, Modules over principal ideal domain and its applications to finitely generated abelian groups.

Section - IV

Noetherian and Artinian modules, Modules of finite length, Noetherian and Artinian rings, Hilbert basis theorem.

$Hom_R(R,R)$, Opposite rings, Wedderburn – Artin theorem, Maschk theorem, Equivalent statement for left Artinian rings having non-zero nilpotent ideals.

Radicals: Jacobson radical, Radical of an Artinian ring.

Note : The question paper of each course 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.

Books Recommended:

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

16MAT21C2: Mathematical Analysis

Time: 03 Hours
Max Marks : 80

Credits : 4:1:0

Course Outcomes

Students would be able to:

CO1 Understand Riemann Stieltjes integral, its properties and rectifiable curves.

CO2 Learn about pointwise and uniform convergence of sequence and series of functions and various tests for uniform convergence.

CO3 Find the stationary points and extreme values of implicit functions.

CO4 Be familiar with the chain rule, partial derivatives and concept of derivation in an open subset of R^n.

Section - I

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

Section - II

Sequence and series of functions, Point wise and uniform convergence, Cauchy criterion for uniform convergence, Weirstrass Mtest, Abel and Dirichlet tests for uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiation, Weierstrass approximation theorem.

Section - III

Power series, uniform convergence and uniqueness theorem, Abel theorem, Tauber theorem. Functions of several variables, Linear Transformations, Euclidean spaceR^n, Derivatives in an open subset of R^n, Chain Rule, Partialderivatives, 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.

Note : The question paper of each course 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.

Books Recommended:

1. Walter Rudin, Principles of Mathematical Analysis (3rd edition) McGraw-Hill, Kogakusha, 1976, International Student Edition.
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. G. De Barra, Measure Theory and Integration, Wiley Eastern Limited, 1981.
5. R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Pub. Co. Pvt. Ltd, 1976.
6. R. G. Bartle, The Elements of Real Analysis, Wiley International Edition, 2011.
7. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International Limited, New Delhi, 2012.

16MAT21C3: Ordinary Differential Equations

Time: 03 Hours *Credits : 4:1:0*
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Apply differential equations to variety of problems in diversified fields of life.
CO2 Learn use of differential equations for modeling and solving real life problems.
CO3 Interpret the obtained solutions in terms of the physical quantities involved in the original problem under reference.
CO4 Use various methods of approximation to get qualitative information about the general behaviour of the solutions of various problems.

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, Picards-Lindelof existence and uniqueness theorem for $dy/dt = f(t,y)$, Solution of initial-value problems by Picards method, Dependence of solutions on initial conditions ***(Relevant topics from the books by Coddington & Levinson, and Ross)***.

Section - II

Linear systems, Matrix method for homogeneous first order system of linear differential equations, Fundamental set of solutions, Fundamental matrix of solutions, Wronskian of solutions, Basic theory of the homogeneous linear system, Abel-Liouville formula, Non-homogeneous linear system.
Strum Theory, Self-adjoint equations of the second order, Abel formula, Strum Separation theorem, Strum 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 points, 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, Asymptotically stable points, Unstable points, Critical points and paths of linear systems. Almost linear systems. **(Relevant topics from chapter 13 of book by Ross)**.

Section - IV

Nonlinear conservative dynamical system, Dependence on a parameter, Liapunov direct method, Limit cycles, Periodic solutions, Bendixson nonexistence criterion, Poincore-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)**.

Note : The question paper of each course 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.

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.

16MAT21C4: Complex Analysis

Time: 03 Hours *Credits : 4:1:0*
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Be familiar with complex numbers and their geometrical interpretations.
CO2 Understand the concept of complex numbers as an extension of the real numbers.
CO3 Represent the sum function of a power series as an analytic function.
CO4 Demonstrate the ideas of complex differentiation and integration for solving related problems and establishing theoretical results.
CO5 Understand concept of residues, evaluate contour integrals and solve polynomial equations.

Section - I

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

Note : The question paper of each course 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.

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. Liang-Shin Hann & Bernand Epstein, Classical Complex Analysis, Jones and Bartlett Publishers International, London, 1996.
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.

Ruel V. Churchill and James Ward Brown, Complex Variables and Applications, McGraw-Hill Publishing Company, 2009.

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

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

16MAT21C5: Mathematical Statistics

Time: 03 Hours [illegible] ***4:1:0***
Max Marks : 80

<u>Course Outcomes</u>
Students would be able to:

CO1 Understand the mathematical basis of probability and its applications in various fields of life.

CO2 Use and apply the concepts of probability mass/density functions for the problems involving single/bivariate random variables.

CO3 Have competence in practically applying the discrete and continuous probability distributions along with their properties.

CO4 Decide as to which test of significance is to be applied for any given large sample problem.

Section - I

Probability: Definition and various approaches of probability, Addition theorem, Boole 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.

Note : The question paper of each course 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.

Books recommended :

1. V. Hogg and T. Craig, Introduction to Mathematical Statistics , 7th addition, Pearson Education Limited-2014
2. A.M. Mood, F.A. Graybill, andD.C. Boes, Introduction to the Theory of Statistics, Mc Graw Hill Book Company.
3. J.E. Freund, Mathematical Statistics, Prentice Hall of India.
4. M. Speigel, Probability and Statistics, Schaum Outline Series.
5. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand Pub., New Delhi.

Scheme of Examination of
M.Sc. Mathematics Semester-II
(w.e.f. Session 2016-17)

Course Code	Title of the Course	Theory Marks	Internal Marks	Practical Marks	Credits (L:T:P)
Core					
16MAT22C1	Theory of Field Extensions	80	20	--	3:1:0
16MAT22C2	Measure and Integration Theory	80	20	--	3:1:0
16MAT22C3	Integral Equations and Calculus of Variations	80	20	--	4:1:0
16MAT22C4	Partial Differential Equations	80	20	--	4:1:0
16MAT22C5	Operations Research Techniques	80	20	--	4:1:0
Foundation Elective					
To be Chosen from the pool of foundation electives provided by the university.					2
Open Elective					
To be Chosen from the pool of open electives provided by the university (excluding the open elective prepared by the Department of Mathematics).					3

Discipline Specific Courses for the students who will not opt for open elective.					
16MM22DO1	Mathematics for Finance and Insurance	80	20	--	3:0:0
16MM22DO2	Statistics through SPSS	40	--	60	1:0:2
				Total Credits :	**28**

Note 1 : The Criteria for awarding internal assessment of 20 marks shall be as under:

A) Class test : 10 marks.
B) Assignment & Presentation : 5 marks
C) Attendance : 5 marks
Less than 65% : *0 marks*
Upto 70% : *2 marks*
Upto 75% : *3 marks*
Upto 80% : *4 marks*
Above 80% : *5 marks*

Note 2 : The syllabus of each course will be divided into **four** Sections of **two** questions each. The question paper of each course 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 contain **eight** short answer type questions without any internal choice covering the entire syllabus.

Note 3 : Elective courses can be offered subject to availability of requisite resources/ faculty.

16MAT22C1: Theory of Field Extensions

Time: 03 Hours — ***Credits : 3:1:0***
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Use diverse properties of field extensions in various areas.

CO2 Establish the connection between the concept of field extensions [illegible] ory

CO3 Describe the concept of automorphism, monomorphism and their [illegible] independe[illegible] in field theory.

CO4 Compute the Galois group for several classical situations.

CO5 Solve polynomial equations by radicals along with the understanding of ruler and compass constructions.

Section - I

Extension of fields: Elementary properties, Simple Extensions, Algebraic and transcendental Extensions. Factorization of polynomials, Splitting fields, Algebraically closed fields, Separable extensions, Perfect fields.

Section - II

Galios theory: Automorphism of fields, Monomorphisms and their linear independence, Fixed fields, Normal extensions, Normal closure of an extension, The fundamental theorem of Galois theory, Norms and traces.

Section - III

Normal basis, Galios fields, Cyclotomic extensions, Cyclotomic polynomials, Cyclotomic extensions of rational number field, Cyclic extension, Wedderburntheorem.

Section - IV

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

Note : The question paper of each course 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.

Books Recommended :

1. I.S. Luther and I.B.S.Passi, Algebra, Vol. IV-Field Theory, Narosa Publishing House, 2012.
2. Ian Stewart, Galios 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 editioin, 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.

16MAT22C2: Measure and Integration Theory

Time: 03 Hours *Credits : 3:1:0*
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Describe the shortcomings of Riemann integral and benefits of Lebesgue integral.
CO2 Understand the fundamental concept of measure and Lebesgue measure.
CO3 Learn about the differentiation of monotonic function, indefinite integral use of t' fundamental theorem of calculus.

Section - I

Set functions, Intuitive idea of measure, Elementary properties of measure, Measurable sets and their fundamental properties. Lebesgue measure of aset of real numbers, Algebra of measurable sets, Borel set, Equivalent formulation of measurable set sin terms of open, Closed, $F_\sigma$and $G_\delta$sets, Nonmeasurable 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 theorem, Lusin theorem, Convergence in measure and F. Riesz theorem. Almostun iform convergence.

Section - III

Short comings 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, Lebesgue theorem regarding points of discontinuities of Riemann integrable functions, Integral of non-negative functions, FatouLemma, Monotone convergence theorem, General Lebesgue Integral, Lebesgue convergence theorem.

Section - IV

Vitalicovering lemma, Differentiation of monotonic functions, Function of bounded variation and its representation as difference of monotonic functions, Differentiation of indefinite integral, Fundamental theorem of calculus, Absolutely continuous functions and their properties.

Note : The question paper of each course 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.

Books Recommended :

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

16MAT22C3: Integral Equations and Calculus of Variations

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes
Students would be able to:

CO1 Understand the methods to reduce Initial value problems as. … li differential equations to various integral equations.

CO2 Categorise and solve different integral equations using various techniques.

CO3 Describe importance of Green's function method for solving boundary value problems associated with non-homogeneous ordinary and partial differential equations, especially the Sturm-Liouville boundary value problems.

CO4 Learn methods to solve various mathematical and physical problems using variational techniques.

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 homonogenous Fredholm equations with degenerate kernels.

Section - III

Green function, Use of method of variation of parameters to construct the Green function for a nonhomogeneous linear second order boundary value problem, Basic four properties of the Green function, Alternate procedure for construction of the Green function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green 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, Geodesic. Fundamental lemma of calculus of variations, Euler 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.

Note : The question paper of each course 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.

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. W.V. Lovitt, *Linear Integral Equations*, McGraw Hill, New York.
4. F.B. Hilderbrand, *Methods of Applied Mathematics*, Dover Publications.
5. J.M. Gelfand and S.V. Fomin, *Calculus of Variations*, Prentice Hall, New Jersy, 1963.

16MAT22C4:Partial Differential Equations

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes
Students would be able to:

CO1 Establish a fundamental familiarity with partial differential e[illegible] nd th[illegible] applications.

CO2 Distinguish between linear and nonlinear partial differential equatio[illegible].

CO3 Solve boundary value problems related to Laplace, heat and wave equations by various methods.

CO4 Use Green's function method to solve partial differential equations.

CO5 Find complete integrals of Non-linear first order partial differential equations.

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.
Laplaceequation – Fundamental solution, Mean value formula, Properties of harmonic functions, Greenfunction.

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).

Note : The question paper of each course 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.

Books Recommended:

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

16MAT22C4:Partial Differential Equations

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes
Students would be able to:

CO1 Establish a fundamental familiarity with partial differential equations and their applications.

CO2 Distinguish between linear and nonlinear partial differential equations.

CO3 Solve boundary value problems related to Laplace, heat and wave equations by various methods.

CO4 Use Green's function method to solve partial differential equations.

CO5 Find complete integrals of Non-linear first order partial differential equations.

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.
Laplaceequation – Fundamental solution, Mean value formula, Properties of harmonic functions, Greenfunction.

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).

Note : The question paper of each course 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.

Books Recommended:

I.N. Sneddon, Elements of Partial Differential Equations, McGraw Hill, New York.
Peter V. O'Neil, Advanced Engineering Mathematics, ITP.

L.C. Evans, Partial Differential Equations: Second Edition (Graduate Studies in Mathematics) 2nd Edition, American Mathematical Society, 2010.
H.F. Weinberger, A First Course in Partial Differential Equations, John Wiley & Sons, 1965.
M.D. Raisinghania, Advanced Differential equations, S. Chand & Co.

16MAT22C5: Operations Research Techniques

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Identify and develop operations research model describing a real life problem.

CO2 Understand the mathematical tools that are needed to solve various optimization problems.

CO3 Solve various linear programming, transportation, assignment, queuing, inventory and game problems related to real life.

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, Transhipment problem. Assignment problems: Hungarian method, Unbalanced problem, Case of maximization, Travelling salesman and crew assignment problems.

Section - III

Concepts of stochastic processes, Poisson process, Birth-death process, Queuing models: Basic components of a queuing system, 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)

Section - IV

Inventory control models: Economic order quantity(EOQ) model with uniform demand, 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; Algebric, Graphical and linear programming methods for solving mixed strategy games.

Note : The question paper of each course 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.

Books recommended :

1. H.A. Taha, Operation Research-An introducton, Printice Hall of India.
2. P.K. Gupta and D.S. Hira, Operations Research, S. Chand & Co.
3. S.D. Sharma, Operation Research, Kedar Nath Ram Nath Publications.
4. J.K. Sharma, Mathematical Model in Operation Research, Tata McGraw Hill.

Scheme of Examination of
M.Sc. Mathematics, Semester-III
(w.e.f. Session 2017-18)

Course Code	Title of the Course	Theory Marks	Internal Marks	Practical Marks	Credit (L:T:P)
Core					
17MAT23C1	Functional Analysis	80	20	--	4:1:0
17MAT23C2	Elementary Topology	80	20	--	4:1:0
17MAT23C3	Fluid Dynamics	80	20	--	4:1:0
Discipline Specific Elective					
Group A (Any One)					
17MAT23DA1	Discrete Mathematics	80	20	--	4:1:0
17MAT23DA2	Fuzzy Set Theory	80	20	--	4:1:0
17MAT23DA3	Mechanics of Solids	80	20	--	4:1:0
17MAT23DA4	Difference Equations	80	20	--	4:1:0
17MAT23DA5	Statistical Inference	80	20	--	4:1:0
17MAT23DA6	Programming in C	60	--	40	3:0:2
Group B (Any One)					
17MAT23DB1	Analytical Number Theory	80	20	--	4:1:0
17MAT23DB2	Advanced Complex Analysis	80	20	--	4:1:0
17MAT23DB3	Mathematical Modeling	80	20	--	4:1:0
17MAT23DB4	Computational Fluid Dynamics	80	20	--	4:1:0
17MAT23DB5	Sampling Techniques and Design of Experiments	80	20	--	4:1:0
17MAT23DB6	Computer Graphics	60	--	40	3:0:2

17MAT23C1: Functional Analysis

Time: 03 Hours
Max Marks : 80

Credits : 4:1:0

Course Outcomes

Students would be able to:

CO1 Be familiar with the completeness in normed linear spaces.

CO2 Understand the concepts of bounded linear transformation, equivalent formulation of continuity and spaces of bounded linear transformations.

CO3 Describe the solvability of linear equations in Banach Spaces, weak and strong convergence and their equivalence in finite dimensional space.

CO4 Learn the properties of compact operators.

CO5 Understand uniform boundedness principle and its consequences.

Section - I

Normed linear spaces, Metric on normed linear spaces, Completion of a normed space, Banach spaces, subspace of a Banach space, Holder and Minkowski 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. Weak sequential compactness, Solvability of linear equations in Banach 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.

Note : The question paper of each course 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.

Books Recommended:

1. H.L. Royden, Real Analysis, MacMillan Publishing Co., Inc., New York, 4th Edition, 1993.
2. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley.
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.

17MAT23C3: Fluid Dynamics

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Be familiar with continuum model of fluid flow and classify fluid/flows based on physical properties of a fluid/flow along with Eulerian and Lagrangian descriptions of fluid motion.

CO2 Derive and solve equation of continuity, equations of motion, vorticityequation, equation of moving boundary surface, pressure equation and equation of impulsive action for a moving inviscid fluid.

CO3 Calculate velocity fields and forces on bodies for simple steady and unsteady f low including those derived from potentials.

CO4 Understand the concepts of velocity potential, stream function and complex potential, and their use in solving two-dimensional flow problems applying complex-variable techniques.

CO5 Represent mathematically the potentials of source, sink and doublets in two-dimensions as well as three-dimensions, and study their images in impermeable surfaces.

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-ordiantes.

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.

Note : The question paper of each course 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.

Books Recommended:

W.H. Besaint and A.S. Ramasey, A Treatise on Hydromechanics, Part II, CBS Publishers, Delhi, 1988.

F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985

O'Neill, M.E. and Chorlton, F., Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986.

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

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

17MAT23DA1: Discrete Mathematics

Time: 03 Hours *Credits : 4:1:0*
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Be familiar with fundamental mathematical concepts and terminology of discrete mathematics and discrete structures.
CO2 Express a logic sentence in terms of predicates, quantifiers and logical connectives.
CO3 Use finite-state machines to model computer operations.
CO4 Apply the rules of inference and contradiction for proofs of various results.
CO5 Evaluate boolean functions and simplify expressions using the properties of boolean algebra.

Section - I

Recurrence Relations and Generating Functions, Some number sequences, Linear homogeneous recurrence relations, Non-homogeneous recurrence relations, Generating functions, Recurrences and generating functions, Exponential generating functions.

Section - II

Statements Symbolic Representation and Tautologies, Quantifiers, Predicates and validity, Prepositional Logic.
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.

Section - III

Boolean Algebras as Lattices, Various Boolean Identities, The switching Algebra.Example, Subalgebras, Direct Products and Homomorphism, Joint-irreducible elements,Atoms and Minterms, Boolean forms and their equivalence, Minterm Boolean forms,
Sum of Products, Cononical forms, Minimization of Boolean functions, Applications ofBoolean 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, Requiting rules, Derivation, Sentential forms, Language generated by a Grammar, Regular, Context -Free and context sensitive grammars and Languages, Regular sets, Regular Expressions and the pumping Lemma.

Note : The question paper of each course 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.

Books Recommended:

Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill, Fourth Edition.

Seymour Lipschutz and Marc Lipson, Theory and Problems of Discrete Mathematics, Schaum Outline Series, McGraw-Hill Book Co, New York.

John A. Dossey, Otto, Spence and Vanden K. Eynden, Discrete Mathematics, Pearson, Fifth Edition.

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

J.E. Hopcraft and J.D.Ullman, Introduction to Automata Theory, Langauages and Computation, Narosa Publishing House.

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

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

Scheme of Examination of
M.Sc. Mathematics, Semester- IV
(w.e.f. Session 2017-18)

Course Code	Title of the Course	Theory Marks	Internal Marks	Practical Marks	Credit (L:T:P)
Core					
17MAT24C1	Inner Product Spaces and Measure Theory	80	20	--	4:1:0
17MAT24C2	Classical Mechanics	80	20	--	4:1:0
17MAT24C3	Viscous Fluid Dynamics	80	20	--	4:1:0
Discipline Specific Elective					
Group C (Any One)					
17MAT24DA1	General Topology	80	20	--	4:1:0
17MAT24DA2	Graph Theory	80	20	--	4:1:0
17MAT24DA3	Applied Solid Mechanics	80	20	--	4:1:0
17MAT24DA4	Bio Mechanics	80	20	--	4:1:0
17MAT24DA5	Information Theory	80	20	--	4:1:0
17MAT24DA6	Object Oriented Programming with C++	60	--	40	3:0:2
Group D (Any One)					
17MAT24DB1	Algebraic Number Theory	80	20	--	4:1:0
17MAT24DB2	Harmonic Analysis	80	20	--	4:1:0
17MAT24DB3	Bio-Fluid Dynamics	80	20	--	4:1:0
17MAT24DB4	Space Dynamics	80	20	--	4:1:0
17MAT24DB5	Stochastic Processes	80	20	--	4:1:0
17MAT24DB6	Information and Communication Technology	60	--	40	3:0:2

Total Credits : 25

Note 1 : The Criteria for awarding internal assessment of 20 marks shall be as under:

A) Class test	:	10 marks.
B) Assignment & Presentation	:	5 marks
C) Attendance	:	5 marks
Less than 65%	:	*0 marks*
Upto 70%	:	*2 marks*
Upto 75%	:	*3 marks*
Upto 80%	:	*4 marks*
Above 80%	:	*5 marks*

Note 2 : The syllabus of each course will be divided into **four** Sections of **two** questions each. The question paper of each course 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 contain **eight** short answer type questions without any internal choice covering the entire syllabus.

Note 3 : Elective courses can be offered subject to availability of requisite resources/ faculty.

faculty.

17MAT24C1: Inner Product Spaces and Measure Theory

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Understand Hilbert spaces and related terms.

CO2 Introduce the concept of projections, measure and outer measure.

CO3 Learn about Hahn, Jordan and Radon-Nikodyn decomposition theorem, Lebesgue-stieltjes integral, Baire sets and Baire measure.

Section - I

Hilbert Spaces: Inner product spaces, Hilbert spaces, Schwarz inequality, Hilbert space as normed linear space,Convex sets in Hilbert spaces, Projection theorem, Orthonormal sets, Separability, Total Orthonormal sets, Bessel inequality, Parseval identity.

Section - II

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. Convex functions, Jensen inequalities, Measure space, Generalized Fatou 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 – Nikodyn theorem,Lebesgue decomposition, Lebesgue - Stieltjes integral, Product measures, Fubini theorem, Baire sets, Baire measure, Continuous functions with compact support.

Note : The question paper of each course 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.

Books Recommended:

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

17MAT24C2: Classical Mechanics

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Be familiar with the concepts of momental ellipsoid, equimomental systems and general motion of a rigid body.

CO2 Understand ideal constrains, general equation of dynamics and Lagrange's equations for potential forces.

CO3 Describe Hamiltonian function, Poincare-Carton integral invariant and principle of

17MAT24C2: Classical Mechanics

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Be familiar with the concepts of momental ellipsoid, equimomental systems and general motion of a rigid body.

CO2 Understand ideal constrains, general equation of dynamics and Lagrange's equations for potential forces.

CO3 Describe Hamiltonian function, Poincare-Carton integral invariant and principle of least action.

CO4 Get familiar with canonical transformations, conditions of canonicity of a transformation in terms of Lagrange and Poisson brackets.

Section –I

Moments and products of inertia, Angular momentum of a rigid body, Principal axes and principal moment 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 & constrained systems, Constraints and their classification, Holonomic and non-holonomic systems, Degree of freedom and generalised coordinates, Virtual displacement and virtual work, Statement of principle of virtual work (PVW), Possible velocity and possible acceleration, Ideal constraints, General equation of dynamics for ideal constraints, Lagrange equations of the first kind. D' Alembert principle,
Independent coordinates and generalized forces, Lagrange equations of the second kind, Generalized velocities and accelerations. Uniqueness of solution, Variation of total energy for conservative fields. Lagrange variable and Lagrangian function L(t, Q_i, $\dot{q}_i$), Lagrange equations for potential forces, Generalized momenta p_i.

Section -III

Hamiltonian variable and Hamiltonian function, Donkin theorem, Ignorable coordinates, Hamilton canonical equations, Routh variables and Routh function R, Routh equations, Poisson Brackets and their simple properties, Poisson identity, Jacobi – Poisson theorem.
Hamilton action and Hamilton principle, Poincare – Carton integral invariant, Whittaker equations, Jacobi equations, Lagrangian action and the principle of least action.

Section -IV

Canonical transformation, Necessary and sufficient condition for a canonical transformation, Univalent Canonical transformation, Free canonical transformation, Hamilton-Jacobi equation, Jacobi theorem, Method of separation of variables in HJ equation, Lagrange brackets, Necessary and sufficient conditions of canonical character of a transformation in terms of Lagrange brackets, Jacobian matrix of a canonical transformation, Conditions of canonicity of a transformation in terms of Poison brackets, Invariance of Poisson Brackets under canonical transformation.

Note : The question paper of each course will consist of **five** Sections. Ea[illegible] **to IV** will contain **two** questions and the students shall be asl[illegible] question from each. **Section-V** shall be **compulsory** and will co[illegible] sh[illegible] answer type questions without any internal choice covering the entire syllabus.

Books Recommended:

F. Gantmacher, Lectures in Analytic Mechanics, MIR Publishers, Moscow, 1975.
P.V. Panat, Classical Mechanics, Narosa Publishing House, New Delhi, 2005.
N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw- Hill, New Delhi, 1991.
Louis N. Hand and Janet D. Finch, Analytical Mechanics, CUP, 1998.
K. Sankra Rao, Classical Mechanics, Prentice Hall of India, 2005.
M.R. Speigal, Theoretical Mechanics, Schaum Outline Series.
F. Chorlton, Textbook of Dynamics, CBS Publishers, New Delhi.

17MAT24C3: Viscous Fluid Dynamics

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Understand about vortex motion and its permanence, rectilinear vertices, vortex images and specific types of rows of vortices.

CO2 Model mathematically the compressible fluid flow and describe various aspects of gas flow.

CO3 Acquire knowledge of viscosity, relation between shear stress and rates of shear strain for Newtonian fluids, energy dissipation due to viscosity, and laminar and turbulent flows.

CO4 Derive the equations of motion for a viscous fluid flow and use them for study of flow Newtonian fluids in pipes and ducts for laminar flow fields, and their applications in mechanical engineering.

CO5 Get familiar with dimensional analysis and similitude, and understand the common dimensional numbers of fluid dynamics along with their physical and mathematical significance.

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. Diffusion of vorticity. Energy dissipation due to viscosity.

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 π-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.

Note : The question paper of each course 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.

Books Recommended:

1. W.H. Besaint and A.S. Ramasey, A Treatise on Hydromechanics, Part II, CBS

17MAT24DA1: General Topology

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Have the knowledge of the separation axioms.
CO2 Understand the concept of product topological spaces and their properties.
CO3 Be familiar with Tychonoff embedding theorem and Urysohn's metrization theorem.
CO4 Know about methods of generating nets and filters and their relations.
CO5 Describe paracompact spaces and their characterizations.

Section - I

Regular, Normal, T_3 and T_4 separation axioms, Their characterization and basic properties, Urysohn 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, Seperation 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(Statement Only).

Section - IV

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

Note : The question paper of each course 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.

Books Recommended:

George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963
K.D. Joshi, Introduction to General Topology, Wiley Eastern Ltd.
J. L. Kelly, General Topology, Springer Verlag, New York, 2000.
J. R. Munkres, Toplogy, Pearson Education Asia, 2002.
W.J. Pervin, Foundations of General Topology, Academic Press Inc. New York, 1964.
K. Chandrasekhara Rao, Topology, Narosa Publishing House Delhi,2009.
Fred H. Croom, Principles of Topology, Cengage Learning, 2009.

17MAT24DA2: Graph Theory

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes
Students would be able to:

CO1 Model real world problems and solve them using basic Graph Theory.
CO2 Understand graph, subgraphs, connected and disconnected graphs etc.
CO3 Differentiate between Hamiltonian and Eulerian graphs.
CO4 Solve problems involving vertex, edge connectivity, planarity and edge coloring.
CO5 Apply tree and graph algorithms to solve problems.

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 Salesperson 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.

Note : The question paper of each course 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.

Books Recommended:

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

17MAT24DA3: Applied Solid Mechanics

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes
Students would be able to:

CO1 Be familiar with the concept of generalized plane stress and solution of two-dimensional biharmonic equations.
CO2 Solve the problems based on thick-walled tube under external and internal pressures.

17MAT24DB1: Algebraic Number Theory

Time: 03 Hours ***Credits : 4:1:0***
Max Marks : 80

Course Outcomes
Students would be able to:

CO1 Learn the arithmetic of algebraic number fields.
CO2 Prove theorems for integral bases and unique factorization into ideals.
CO3 Factorize an algebraic integer into irreducibles.
CO4 Obtain the ideals of an algebraic number ring.
CO5 Understand ramified and unramified extensions and their related results.

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(ω) where $\omega^3 = 1$, Algebraic fields, Primitive polynomials, The general quadratic field Q(√m), Units of Q(√2), Fields in which fundamental theorem is false, Real and complex Euclidean fields, Fermat theorem in the ring of Gaussian integers, Primes of Q(√2) and Q(√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.

Note : The question paper of each course 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.

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.