Scheme of Examination of M.Sc. Mathematics
Programme Code: MAT2
Semester- I
(w.e.f. Session 2019-20)

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.

Scheme of Examination of
M.Sc. Mathematics Semester-II
(w.e.f. Session 2019-20)

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

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.

Scheme of Examination of
M.Sc. Mathematics, Semester-III
(w.e.f. Session 2020-21)

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

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

Total Credits : 31

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.

Scheme of Examination of
M.Sc. Mathematics, Semester- IV
(w.e.f. Session 2020-21)

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.

16MAT21C1: Abstract Algebra

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

<u>Course Outcomes</u>
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 ***Credits : 4:1:0***
Max Marks : 80

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

<u>Course Outcomes</u>

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, E*lementary 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 ***Credits : 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 , 7^{th} 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.

16MAT22C1: Theory of Field Extensions

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

<u>Course Outcomes</u>

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 and Galois theory.
CO3 Describe the concept of automorphism, monomorphism and their linear independence 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 the 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 associated with linear 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, I*ntroduction to Integral Equations with Applications, A* Wiley-Interscience Publication, 1999.
2. R.P. Kanwal, L*inear Integral Equations*, Theory and Techniques, Academic Press, New York.
3. W.V. Lovitt, L*inear Integral Equations*, McGraw Hill, New York.
4. F.B. Hilderbrand, M*ethods of Applied Mathematics*, Dover Publications.
5. J.M. Gelfand and S.V. Fomin, C*alculus 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 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

<u>Course Outcomes</u>

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.

16MAT22SO1 : Mathematics for Finance and Insurance

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

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

CO1 Demonstrate knowledge of the terminology related to nature, scope, goals, risks and decisions of financial management.
CO2 Predict various types of returns and risks in investments and take necessary protective measures for minimizing the risk.
CO3 Develop ability to understand, analyse and solve problems in bonds, finance and insurance.
CO4 Build skills for computation of premium of life insurance and claims for general insurance using probability distributions.

Section - I

Financial Management –overview. Nature and scope of financial management. Goals and main decisions of financial management. Difference between risk, Speculation and gambling.
Time value of Money - Interest rate and discount rate. Present value and future value-discrete case as well as continuous compounding case. Annuities and its kinds.

Section - II

Meaning of return. Return as Internal Rate of Return (IRR). Numerical methods like Newton Raphson method to calculate IRR. Measurement of returns under uncertainty situations. Meaning of risk. Difference between risk and uncertainty. Types of risks. Measurements of risk. Calculation of security and Portfolio Risk and Return-Markowitz Model. Sharpe Single Index Model- Systematic Risk and Unsystematic Risk.

Section - III

Taylor series and Bond Valuation. Calculation of Duration and Convexity of bonds.
Insurance Fundamentals – Insurance defined. Meaning of loss. Chances of loss, Peril, Hazard, proximate cause in insurance. Costs and benefits of insurance to the society and branches of insurance-life insurance and various types of general insurance. Insurable loss exposures- feature of a loss that is ideal for insurance.

Section - IV

Life Insurance Mathematics – Construction of Morality Tables. Computation of Premium of Life Insurance for a fixed duration and for the whole life. Determination of claims for General Insurance – Using Poisson Distribution and Negative Binomial Distribution –the Polya Case.
Determination of the amount of Claims of General Insurance – Compound Aggregate claim model and its properties, Claims of reinsurance. Calculation of a compound claim density function F, Recursive and approximate formulae for F.

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. Aswath Damodaran, Corporate Finance - Theory and Practice, John Wiley & Sons, Inc.
2. John C. Hull, Options, Futures, and Other Derivatives, Prentice-Hall of India Private Ltd.

3. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge University Press.
4. Mark S. Dorfman, Introduction to Risk Management and Insurance, Prentice Hall, Englwood Cliffs, New Jersey.
5. C.D. Daykin, T. Pentikainen and M. Pesonen, Practical Risk Theory for Actuaries, Chapman & Hall.
6. Salih N. Neftci, An Introduction to the Mathematics of Financial Derivatives, Academic Press, Inc.
7. Robert J. Elliott and P. Ekkehard Kopp, Mathematics of Financial Markets, Sprigner-Verlag, New York Inc.

16MAT22SO2: Statistics through SPSS

Credits : 1:0:2

Course Outcomes

Students would be able to:

CO1 Understand different types of data and scales of their measurement.

CO2 Learn basic workings of SPSS and perform a wide range of data management tasks in SPSS.

CO3 Obtain descriptive statistics and basic inferential statistics for comparisons using SPSS.

CO4 Apply basic statistical parametric and non-parametric tests for the given data.

CO5 Carry out correlation, regression and factor analysis through the use of SPSS.

Part-A (Theory)

Time: 03 Hours
Max Marks: 40

Section – I

Data: Qualitative and quantitative data, Cross-sectional and time series data, Univariate and multivariate data. Scales of measurement of data.
SPSS data file: Opening a data file in SPSS, SPSS Data Editor, Creating a data file, Editing and manipulating data, Missing values, Editing SPSS output, Copying SPSS output, Printing from SPSS, Importing data.

Section – II

Descriptive statistics with SPSS: Measures of central tendency, Dispersion, Skewness, Kurtosis.
Charts and graphs with SPSS: Frequencies, Bar charts, Pie charts, Line graphs, Histograms, Box plots.

Section – III

Statistical tests using SPSS: Normality tests, t-tests, F-test, One way and Two way ANOVA, Non-parametric tests- Chi Square, Spearman rank, Maan Whitney U and Wilcoxon signed rank test.

Section – IV

Correlation and regression using SPSS: Linear correlation and regression, Multiple regression.
Factor analysis using SPSS.

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. S.L. Gupta and H. Gupta, SPSS for Researchers, International Book House Pvt. Ltd.
2. A. Field, Discovering Statistics using SPSS, SAGE Publications.
3. V. Gupta, SPSS for Beginners, VJ Books Inc.
4. A. Rajathi and P. Chandran, SPSS for you, MJP Publishers

Part-B (Practical)

Time: 03 Hours
Max Marks: 60

There will be a separate practical course based on the above theory course. All practicals are required to be done using SPSS (i.e. **16MAT22SO2: Statistics through SPSS).**

17MAT23C1: Functional Analysis

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

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.

17MAT23C2: Elementary Topology

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

Course Outcomes

Students would be able to:

CO1 Get familiar with the concepts of topological space and continuous functions.
CO2 Generate new topologies from a given set with bases.
CO3 Describe the concept of homeomorphism and topological invariants.
CO4 Establish connectedness and compactness of topological spaces and proofs of related theorems.
CO5 Have in-depth knowledge of separation axioms and their properties.

Section - I

Definition and examples of topological spaces, Comparison of topologies on a set, Intersection and union of topologies on a set, Neighbourhoods, Interior point and interior of a set , Closed set as a complement of an open set , Adherent point and limit point of a set, Closure of a set, Derived set, Properties of Closure operator, Boundary of a set , Dense subsets, Interior, Exterior and boundary operators, Alternative methods of defining a topology in terms of neighbourhood system and Kuratowski closure operator.

Section - II

Relative(Induced) topology, Base and subbase for a topology, Base for Neighbourhood system. Continuous functions, Open and closed functions , Homeomorphism. Connectedness and its characterization, Connected subsets and their properties, Continuity and connectedness, Components, Locally connected spaces.

Section - III

Compact spaces and subsets, Compactness in terms of finite intersection property, Continuity and compact sets, Basic properties of compactness, Closeness of compact subset and a continuous map from a compact space into a Hausdorff and its consequence. Sequentially and countably compact sets, Local compactness and one point compatification.

Section - IV

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, Lindelof theorem. T_0, T_1, T_2 (Hausdorff) separation axioms, their characterization and basic 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 :

C.W.Patty, Foundation of Topology, Jones & Bertlett, 2009.
Fred H. Croom, Principles of Topology, Cengage Learning, 2009.
George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.
J. L. Kelly, General Topology, Springer Verlag, New York, 2000.
J. R. Munkres, Toplogy, Pearson Education Asia, 2002.
K. Chandrasekhara Rao, Topology, Narosa Publishing House Delhi,2009.

K.D. Joshi, Introduction to General Topology, Wiley Eastern Ltd, 2006.

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.

17MAT23DA2: Fuzzy Set Theory

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

<u>Course Outcomes</u>

Students would be able to:

CO1 Draw a parallelism between crisp set operations and fuzzy set operations through the use of characteristic and membership functions respectively.

CO2 Learn fuzzy sets using linguistic words and represent these sets by membership functions.

CO3 Define mapping of fuzzy sets by a function and fuzzy-set-related notions; such as α-level sets, convexity, normality, support, etc.

CO4 Know the concepts of fuzzy graph, fuzzy relation, fuzzy morphism and fuzzy numbers.

CO5 Become familiar with the extension principle, its compatibility with the α-level sets and its usefulness in performing fuzzy number arithmetic operations.

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]).

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. 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.

17MAT23DA3: Mechanics of Solids

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

<u>Course Outcomes</u>

Students would be able to:

CO1 Get familiar with Cartesian tensors, as generalization of vectors, and their properties which are used in the analysis of stress and strain to describe the phenomenon of solid mechanics.

CO2 Analyse the basic properties of stress and strain components, their transformations, extreme values, invariants and Saint-Venant principle of elasticity.

CO3 Demonstrate generalized Hooke's law for three dimensional elastic solid which provides the linear relationship between stress components and strain components.

CO4 Use different types of elastic symmetries to derive the stress-strain relationship for isotropic elastic materials for applications to architecture and engineering.

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.

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. Sokolnikoff, M*athematical theory of Elasticity*, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1977.
2. Teodar M. Atanackovic and Ardeshiv Guran, T*heory 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, C*ontinuum Mechanics*, Academic Press, 1994.

5. Jeffreys, H., *Cartesian tensor*s.
6. A.K. Mal & S.J. Singh, D*eformation of Elastic Solids*, Prentice Hall, New Jersey, 1991.

17MAT23DA4:Difference Equations

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

<u>Course Outcomes</u>

Students would be able to:

CO1 Be familiar with the difference equation and various types of difference operators.
CO2 Derive and solve difference equations.
CO3 Apply the concepts of stability of linear and nonlinear systems.
CO4 Get knowledge of phase plane analysis for linear systems.
CO5 Understand the concept of asymptotic methods for linear and nonlinear equations. Also explain the chaotic behaviour of solutions.

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.

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.

Recommended Books:

Walter Kelley and Allan Peterson, Difference Equations, An Introduction with Applications, Academic Press

Calvin Ahlbrant and Allan Peterson, Discrete Hamiltonian Systems, Difference Equations, Continued Fractions and Riccati Equations, Kluwer (1996).

Saber Elaydi, An Introduction to Difference Equations, Springer

17MAT23DA5: Statistical Inference

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

Course Outcomes

Students would be able to:

CO1 Understand the concepts of point estimation and interval estimation.
CO2 Identify good estimators using criterion of good estimators and obtain estimators using method of maximum likelihood and moments.
CO3 Learn about the chi-square, Students' t and Snedcor F-statistics and their important applications.
CO4 Carry out different tests of significance for small samples and apply common non-parametric tests to real life problems.
CO5 Explain and use Neyman-Pearson lemma and likelihood ratio tests.

Section – I

Point and interval estimation, Unbiasedness, Efficiency, Consistency and Sufficiency. Methods of maximum likelihood and Moments for estimation.

Section – II

Definition of Chi-square statistic, Chi-square tests for goodness of fit and independence of attributes. Definition of Student 't' and Snedcor F-statistics. Testing for the mean and variance of univariate normal distributions, Testing of equality of two means and two variances of two univariate normal distributions. Related confidence intervals.

Section – III

Neyman-Pearsonlemma, Liklihood ratio tests. Tests for mean and variance of a normal population, Equality of means and variances of two normal populations.

Section – IV

Definition of order statistics and their distributions, Non-parametric tests, Sign test for uni-variate and bi-variate distribution, Run test, Median test and Mann Whitney-U-test.

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.M. Mood, F.A. Graybill and D.C. Boes, Introduction to the theory of Statistics, McGraw Hill, 1974.
2. A.M. Goon, M.K. Gupta, and B. Das Gupta, Fundamentals of Statistics, Vol-II.
3. R.V. Hogg and A.T. Craig, Introduction to Mathematical Statistics.
4. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 2002.

17MAT23DA6: Programming in C

Credits : 3:0:2

Course Outcomes

Students would be able to:

CO1 Write and run a C program along with gradual improvement using efficient error handling.

CO2 Implement selective structures and repetitive structures in C programs using different control statements.

CO3 To emphasize on the importance of use of pointers for efficient C programming.

CO4 Use structures and unions in a C program for handling multivariate data.

CO5 Efficient management of memory space of the system by using compact C statements and Dynamic memory allocation functions.

Part-A (Theory)

Time : 03 Hours
Max Marks : 60

Section - I

An overview of Programming, Programming Language, Classification. Basic structure of a C Program, C language preliminaries.

Operators and Expressions, Bit - Manipulation Operators, Bitwise Assignment Operators, Decisions and looping.

Section - II

Arrays and Pointers, Encryption and Decryption. Pointer Arithmetic, Passing Pointers as Function Arguments, Accessing Array Elements through Pointers, Passing Arrays as Function Arguments. Multidimensional Arrays. Arrays of Pointers, Pointers to Pointers.

Section - III

Storage Classes –Fixed vs. Automatic Duration. Scope. Global Variables. Definitions and Allusions. The Register Specifier. ANSI rules for the Syntax and Semantics of the Storage-Class Keywords. Dynamic Memory Allocation.

Structures and Unions. *enum* declarations. Passing Arguments to a Function, Declarations and Calls, Automatic Argument Conversions, Pointers to Functions.

Section - IV

The C Preprocessors, Macro Substitution. Include Facility. Conditional Compilation. Line Control.

Input and Output -Streams. Buffering. Error Handling. Opening and Closing a File. Reading and Writing Data. Selecting an I/O Method. Unbuffered I/O. Random Access. The Standard Library for I/O.

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. Peter A. Darnell and Philip E. Margolis, C : A Software Engineering Approach, Narosa Publishing House (Springer International Student Edition) 1993.
2. Samuel P. Harkison and Gly L. Steele Jr., C : A Reference Manual, Second Edition, Prentice Hall, 1984.
3. Brian W. Kernighan & Dennis M. Ritchie, The C Programme Language, Second Edition (ANSI features) , Prentice Hall 1989.

4. Balagurusamy E : Programming in ANSI C, Third Edition, Tata McGraw-Hill Publishing Co. Ltd.
5. Byron, S. Gottfried : Theory and Problems of Programming with C, Second Edition (Schaum Outline Series), Tata McGraw-Hill Publishing Co. Ltd.
6. Venugopal K. R. and Prasad S. R.: Programming with C , Tata McGraw-Hill Publishing Co. Ltd.

Part-B (Practical)

Time: 03 Hours
Max Marks : 40
There will be a separate practical course based on the above theory course (i.e. **17MAT23DA6: Programming in C)**.

17MAT23DB1: Analytical Number Theory

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

Course Outcomes

Students would be able to:

CO1 Know about the classical results related to prime numbers and get familiar with the irrationality of *e* and *Π*.

CO2 Study the algebraic properties of U_n and Q_n.

CO3 Learn about the Waring problems and their applicability.

CO4 Learn the definition, examples and simple properties of arithmetic functions and about perfect numbers.

CO5 Understand the representation of numbers by two or four squares.

Section - I

Distribution of primes, Fermat and Mersenne numbers, Farey series and some results concerning Farey series, Approximation of irrational numbers by rationals, Hurwitz 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) & G(k), Lower bounds for g(k) & G(k).

Section - IV

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

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

17MAT23DB2: Advanced Complex Analysis

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

Course Outcomes

Students would be able to:

CO1 Understand the concepts of Gamma function and its properties.

CO2 Get familiar with Riemann Zeta function, Riemann functional equation and Mittag Leffler theorem.

CO3 Demonstrate the idea of Harnack Inequality, Dirichlet region, Green function and its properties.

CO4 Understand the concept of integral functions, their factorisation, order and exponent of convergence.

CO5 Be familiar with the range of analytic function and proof of related results.

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" .

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. 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 & Bernand Epstein, 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.

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

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

17MAT23DB3: Mathematical Modeling

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

<u>Course Outcomes</u>

Students would be able to:

CO1 Understand the core principles of mathematical modeling.
CO2 Apply precise and logical reasoning to problem solving.
CO3 Frame quantitative problems and model them mathematically.
CO4 Analyze the importance of partial differential equations in mathematical modeling.
CO5 Formulate the observable real problem mathematically.

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.

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. 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. Mathematical Models in the Social, Management and Life Sciences, D.N. Burghes and A.D. Wood, John Wiley & Sons.
4. Mathematical Modeling, J.G. Andrews & R.R Mclone, Butterworths (Pub.) Inc.

17MAT23DB4: Computational Fluid Dynamics

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

Course Outcomes

Students would be able to:

CO1 Possess a good understanding of the basics of fluid mechanics and the governing equations of the fluid dynamics.

CO2 Learn the art of numerical methods employed in computational aspects of fluid dynamics and related applications.

CO3 Acquire a good knowledge of the mathematical concepts of the finite difference and finite volume discretizations.

CO4 Describe the major theories, approaches and the methodologies used in CFD along with their limitations on accuracy.

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.

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. 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.
   J.D. Anderson, Computational Fluid Dynamics : The basics with applications, McGraw-Hill, 1995.
   K. Muralidher, Computational Fluid Flow and Heat Transfer, Narosa Pub. House.
3. T.J. Chung, Computational Fluid Dynamics, Cambridge Uni. Press.
4. J.N. Reddy, An introduction to the Finite Element Methods,McGraw Hill International Edition, 1985.

17MAT23DB5: Sampling Techniques and Design of Experiments

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

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

CO1 Understand the applicability of sample survey over the complete enumeration and vice-versa.
CO2 Distinguish between simple random sampling, stratifies random sampling and systematic sampling, and to learn under what situations which type of sampling technique is applicable.
CO3 Give complete analysis of completely randomised, randomized block and latin square designs and solve various related problems.
CO4 Have the skill of solving problems on Factorial designs – 2^2 and 2^3 designs.

Section -I

Concepts of census and sample survey, Principal steps involved in a sample survey, sampling and non-sampling errors, Bias, Precision and accuracy.
Simple random sampling (SRS) with and without replacement. Use of random number tables, Estimate of population mean and its variance in case of simple random sampling, Simple random sampling of attributes.

Section -II

Stratified random sampling, Estimate of population mean and its variance in case of stratified sampling; Proportional and optimum allocation; Comparison of stratified random sampling with simple random sampling without stratification. Idea of systematic sampling and its various results (without derivation).

Section -III

Terminology in experimental designs: Experiment, Treatments, experimental unit, Blocks, Yield, Experimental error, Replication, Precision, Efficiency of a design, Uniformity trials; Fundamental principles of experimental design, Size and shape of plots and blocks; Layout and analysis of completely randomised design (CRD) and randomised block design (RBD); Efficiency of RBD relative to CRD.

Section -IV

Latin Square Design (LSD) and its analysis, Efficiency of LSD relative to RBD and CRD. Factorial designs – 2^2 and 2^3 designs, Illustrations, Main effects, Interaction effects and analysis of these designs.

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.G. Chochran, Sampling Techniques.
2. F.S. Chaudhary andD. Singh, Theory & Analysis of Sample Survey.
3. A.M. Goon, M.K. Gupta andB. Das Gupta, Basic Statistics, World Press.
4. S.C. Gupta andV.K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand Pub., New Delhi.

17MAT23DB6:Computer Graphics

Credits : 3:0:2

<u>Course Outcomes</u>

Students would be able to:

CO1 Gain programming skills in C language for writing applications that produce 2D and 3D computer graphics.

CO2 Learn the principles and commonly used paradigms and techniques of computer graphics.

CO3 Write basic graphics application programs including animation.

CO4 Design and code programs for 2-D and 3-D transformations, clipping, filling area and hidden surface removal.

<u>Part-A (Theory)</u>

Time : 03 Hours
Max Marks : 60

Section – I

Introduction to Computer Graphics: What is Computer Graphics, Computer Graphics Applications, Two Dimensional Graphics Primitives C Graphics Introduction: Graphics Mode Initialization in C, C Graphics Functions Line drawing algorithms: DDA, Bresenham Line Drawing Algorithm. Circle drawing algorithms: Bresenhamcircle drawing, Midpoint circle drawing algorithm.

Section - II

Two/Three Dimensional Viewing: The 2-D Viewing Pipeline, Windows, Viewports, Window to View Port Mapping.

Two dimensional transformations: Transformations, Translation, Scaling, Rotation, Reflection, Composite Transformation.

Three dimensional transformations: Three dimensional graphics concept, Matrix representation of 3-D Transformations, Composition of 3-D transformation.

Section - III

Clipping: Point and Line Clipping - 4 Bit Code Algorithm, Sutherland-Cohen Algorithm Polygon Clipping: Sutherland-Hodgeman Polygon Clipping Algorithm.

Section – IV

Filled area algorithms: Scanline Polygon filling algorithm, Boundary filled algorithm. Hidden surface removal: Introduction to hidden surface removal. The Z- buffer algorithm, Scanline algorithm, Area sub divisional gorithm.

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:

Computer Graphics Principles and Practices second editionby James D. Foley, andeies van Dam, Stevan K. Feinerand Johb F. Hughes, 2000, Addision Wesley.

Computer Graphics by Donald Hearn and M.Pauline Baker,2nd Edition, 1999, PHI
Procedural Elements for Computer Graphics – David F.Rogers, 2001, T.M.H Second Edition
Fundamentals of 3Dimensional Computer Graphics by AlanWatt, 1999, Addision Wesley.
Computer Graphics: Secrets and Solutions by Corrign John,BPB
Graphics, GUI, Games & Multimedia Projects in C byPilania&Mahendra, Standard Publ.
Computer Graphics Secrets and solutions by Corrign John,1994, BPV
Introduction to Computer Graphics By N. KrishanmurthyT.M.H 2002

Part-B (Practical)

Time: 03 Hours
Max Marks : 40

There will be a separate practical course based on the above theory course (i.e. **17MAT23DB6: Computer Graphics)**.

17MAT23SO1: Multivariate Analysis

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

<u>Course Outcomes</u>

Students would be able to:

CO1 Perform exploratory analysis of multivariate data.
CO2 Test for multivariate normality of the data.
CO3 Apply multivariate statistical methods for testing of hypothesis and estimation.
CO4 Perform data reduction using principal component analysis.
CO5 Apply multivariate techniques to study the population structure.

Section - I

Multivariate normal distribution, Marginal and conditional distributions, Characteristic function. Distribution of linear combinations of normal vector

Section - II

Maximum likelihood estimators of mean vector and covariance matrix. Distribution of sample mean vector, Distribution of quadratic forms. Correlation coefficient of a bivariate sample, Partial and multiple correlation coefficients.

Section - III

Derivation of generalised T^2-statistic and its distribution, Uses of T^2-statistic. The problem of classification, Procedures of classification of one of the two populations with known probabilities. Wishart matrix - its distribution(without proof) and properties. Generalized variance.

Section - IV

Principal components, Maximum likelihood estimators of principal components and their variances. Canonical correlations and variates, Estimation of canonical correlations and variates. Cluster analysis.

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

T.W. Anderson, An Introduction to Multivariate Statistical Analysis, John Wiley
C.R. Rao, Linear Statistical Inference and its Applications, John Wiley
R.A. Johnson and D.W. Wichern, (2001), Applied Multivariate Statistical Analysis, Prentice Hall of India
A.C. Rencher, (2002), Methods of Multivariate Analysis, 2nd Ed., John Wiley &Sons.

17MAT23SO2: MATLAB

Credits : 1:0:2

Course Outcomes

Students would be able to:

CO1 Know the basic concepts of MATLAB software.

CO2 Understand the procedures, algorithms, and concepts required in solving specific problems.

CO3 Code solutions to problems in MATLAB, in a legible, debug' able and efficient way.

CO4 Solve different types of mathematical problems and draw various types of graphs using MATLAB.

Part-A (Theory)

Time : 03 Hours
Max Marks : 40

Section-I

Introduction to MATLAB Programming: Basics of MATLAB programming, Anatomy of a program, Variables and assignments, Data types, Operators, Working with complex numbers, Mathematical operations, Functions for input and output, Good programming style. Introduction to vectors in Matlab: Defining a Vector, Accessing elements within a vector, Basic operations on vectors

Section-II

Strings, String functions, Cell array, Creating cell array, Introduction to Matrices in Matlab: Defining Matrices, Matrix functions, Matrix operations, Vector functions Loops: for loops, While loops, Branching (conditional statements) - if statement, If else statement, Else if statement, Executable files, Subroutines, Built in functions and user-defined functions, Function handles, Function handles in m-files, Inline functions.

Section-III

Linear Algebra: Solving a linear system, Finding eigen values and eigenvectors, Polynomial curve fitting on fly, Curve fitting with polynomial functions, Least squares curve fitting, General nonlinear fits, Interpolation, Data Analysis and Statistics, Numerical Integration, Ordinary Differential Equations: A first order linear ODE, A second order nonlinear ODE, Ode23 versus ode45, Nonlinear Algebraic Equations, Roots of polynomials.

Section-IV

Data files: Saving and recalling data, Saving a session as text, C style read/write, Graphs and plots- Basic 2-D plots, Overlay plots, Specialized 2-D plots, 3-D plots, Interpolated surface plots, Using subplots for multiple graphs, Saving and printing graphs, Mesh, Contour, Contourf, Using built-in algorithms: optimization and numerical integration (areas), Root-finding.

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. Amos Gilat, MATLAB An Introduction With Applications 5ed, Publisher: Wiley.
2. C. F. Van Loan and K.-Y. D. Fan., Insight through Computing: A Matlab Introduction to Computational Science and Engineering, SIAM Publication, 2009.
3. Y.Kirani Singh, B.B. Chaudhari, MATLAB Programming, PHI Learning, 2007.
4. Krister Ahlersten, An Introduction to Matlab, Bookboon.com.
5. Rudra Pratap, Getting Started with MATLAB, Oxford University Press.

<u>Part-B (Practical)</u>

Time: 03 Hours
Max Marks : 60

There will be a separate practical course based on the above theory course (i.e. **17MAT23SO2: MATLAB)**.

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

<u>Course Outcomes</u>
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**, G**eneral 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. 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:

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 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.

17MAT24DA1: General Topology

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

<u>Course Outcomes</u>
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

<u>Course Outcomes</u>
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.
CO3 Understand the concept of torsional rigidity, lines of shearing stress and solve the problems of torsion of beams with different cross-sections.
CO4 Describe Ritz method, Galerkin method, Kantrovich method and their applications to the torsional problems.
CO5 Get familiar with simple harmonic progressive waves, plane waves and wave propagation in two-dimensions.

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 streched 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 & SH waves.

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. Sokolnikof, M*athematical theory of Elasticity*, Tata McGraw Hill Publishing company Ltd. New Delhi, 1977.
2. Teodar M. Atanackovic and Ardeshiv Guran, T*heory of Elasticity for Scientists and Engineers, B*irkhausev, Boston, 2000.
3. A.K. Mal & S.J. Singh, D*eformation of Elastic Solids*, Prentice Hall, New Jersey, 1991.
4. C.A. Coluson*, Waves.*
5. A.S. Saada, E*lasticity-Theory and Applications*, Pergamon Press, New York, 1973.
6. D.S. Chandersekharian and L.Debnath, C*ontinuum Mechanics*, Academic Press.

17MAT24DA4: Bio Mechanics

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

Course Outcomes

Students would be able to:

CO1 Use the mathematics of mechanics to quantify the kinematics and kinetics of human movement alongwith describing its qualitative analysis.

CO2 Possess knowledge of steady laminar flow in elastic tubes, pulsatile flow and significance of non-dimensional number affecting the flow.

CO3 Study the problems of external flow around bodies moving in wind and water, in locomotion, flying and swimming.

CO4 Be familiar with internal flows such as blood flow in blood vessels, gas in lungs, urine in kidneys, water and other body fluids in interstitial space between blood vessels and cells.

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 macrocirculation 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 microcirculation.

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

17MAT24DA5: Information Theory

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

<u>Course Outcomes</u>

Students would be able to:

CO1 Understand various measures of information with proofs of important properties of information measures.
CO2 Learn the basic concepts of noiseless coding, channel and channel capacity and relation among them.
CO3 Compare different codes and construct optimal codes.
CO4 Explain important discrete memoryless channels and continuous channels.
CO5 Analyse information processed by the channels and obtain channel capacity.

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.

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. 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.

17MAT24DA6 :Object Oriented Programming with C++

Credits : 3:0:2

Course Outcomes

Students would be able to:

CO1 Apply C++ features to design and implement a program.

CO2 Develop solutions to problems demonstrating usage of data abstraction, encapsulation and inheritance.

CO3 Program using C++ features such as operators overloading, polymorphism, streams, exception handling etc.

CO4 Implement practical applications and analyze issues related to object-oriented techniques in the C++ programming language.

Part-A (Theory)

Time : 03 Hours
Max Marks : 60

Section - I

Basic concepts of Object-Oriented Programming (OOP). Advantages and applications of OOP. Object-oriented languages. Introduction to C++. Structure of a C++ program. Creating the source files. Compiling and linking.

C++ programming basics: Input/Output, Data types, Operators, Expressions, Control structures, Library functions.

Section - II

Functions in C++ : Passing arguments to and returning values from functions, Inline functions, Default arguments, Function overloading.

Classes and objects : Specifying and using class and object, Arrays within a class, Arrays of objects, Object as a function arguments, Friendly functions, Pointers to members.

Section - III

Constructors and destructors. Operator overloading and type conversions.

Inheritance : Derived class and their constructs, Overriding member functions, Class hierarchies, Public and private inheritance levels.

Polymorphism, Pointers to objects, This pointer, Pointers to derived classes, Virtual functions.

Section - IV

Streams, Stream classes, Unformatted Input/Output operations, Formatted console Input/Output operations, Managing output with manipulators.

Classes for file stream operations, Opening and Closing a file. File pointers and their manipulations, Random access. Error handling during file operations, Command-line arguments. Exceptional handling.

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. Robert Lafore, Waite Group Object Oriented Programming using C++, Galgotia Pub.
2. E. Balagrusamy, Object Oriented Programming with C++, 2nd Edition, Tata Mc Graw Hill Pub. Co.
3. Byron, S. Gottfried, Object Oriented Programming using C++, Schaum Outline Series, Tata Mc Graw Hill Pub. Co.
4. J.N. Barakaki, Object Oriented Programming using C++, Prentic Hall of India, 1996.

Part-B (Practical)

Time: 03 Hours
Max Marks : 40

There will be a separate practical course based on the above theory course (i.e. **17MAT24DA6 :Object Oriented Programming with C++)**.

17MAT24DB1: Algebraic Number Theory

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

<u>Course Outcomes</u>
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.

17MAT24DB2: Harmonic Analysis

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

Course Outcomes

Students would be able to:

CO1 Understand the concept of Fourier series and Fourier transformation using various theorems.

CO2 Learn about Poisson kernel and its properties, Poisson integral of L1 function and Poisson measure.

CO3 Study the boundary behaviour of Poisson integral.

CO4 Operate with Hardy spaces, use the Poisson integral and canonical factorization theorem.

Section - I

Fourier series and some special kernals, Fourier transforms and its properties, Convolution theory, Approximate identities, Plancherel's theorem, Harnack's Theorem, Mean value property.

Section -II (2 Questions)

Summability of Fourier series, Fourier series of $f \in L^2$ (T), Bessel's inequality, Riemann-Lebesgue lemma, Best approximation theorem, Parseval's Theorem, Poisson integral of a measure, Boundary behavior of Poisson integrals, Maximal functions, Non-tangential limits.

Section-III (2 Questions)

Subharmonic functions in upper half-plane, Hardy Spaces H^p over the unit disc, H^p as a Banach space, Boundary behavior of Hardy Space over the upper half-plane, Canonical factorization, Cauchy integrals , Paley- Wiener theorem.

Section–IV (2 Questions)

Blaschke product and its properties, Theorem of F and M Riesz, Inner and outer functions.Trigonometric Series, Conjugate Functions, Theorem of M. Riesz, Kolomogrov Theorem, Zygmund Theorem, Hardy- Littlewood 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. Peter L. Duren : Theory of H^p Spaces, Academic Press.
2. Walter Rudin : Real and Complex Analysis, Third Edition, Mc Graw Hill Book Co.
3. J.B. Carnett : Bounded Analysis Functions, Academic Press.
4.Y. Katznelson : An Introduction to Harmonic Analysis, John Wiley, 1968.
5. R. Lasser : Introduction to Fourier Series, Marcel Dekker.
6. K. Hoffman : Banach Spaces of Analytic Functions, New York.

17MAT24DB3:Bio-Fluid Dynamics

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

<u>Course Outcomes</u>

Students would be able to:

CO1 Understand the basic concepts of physiological and biological fluid dynamics.
CO2 Know about the systematic and pulmonary circulations, specific flow properties of blood and identify diseases related to obstruction of blood flow in human body.
CO3 Get familiar with important models of bio-fluid flows and their applications to duct and pipe flows.
CO4 Able to describe non-Newtonian fluid flow models and peristaltic flows along with their applications in blood flow in human body.

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.

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:

- Jagan N. Mazumdar; Biofluid Mechanics, World Scientific Pub.
- J.N. Kapur; Mathematical Models in Biology and Medicine, Affiliated East-West Press Pvt. Ltd.

- T.J. Pedley; The Fluid Mechanics of Large Blood Vessels, Cambridge Uni. Press, 1980.
- M. Stanley; Transport Phenomenon in Cardiovascular System, 1972.
- O'Neill, M.E. and Chorlton, F. , Viscous and Compressible Fluid Dynamics, Ellis Horwood Limited, 1989.
- J. L. Bansal, Viscous Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 2000.

17MAT24DB4: Space Dynamics

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

Course Outcomes

Students would be able to:

CO1 Have a good understanding of orbiting bodies.
CO2 Solve body problems analytically by using Hamilton Jacobi theory.
CO3 Find stationary solutions and stability of dynamical system.
CO4 Be familiar with perturbations such as perturbing forces, secular and periodic perturbations on body problems.

Section - I

Basic formulae of a spherical triangle. The two-body problem. The motion of the center of mass. The relative motion. Kepler's equation. Solution by Hamilton Jacobi theory.

Section - II

The determination of orbits – Laplace's Gauss methods. The three-body problem. General three body problem. Restricted three body problem.

Section - III

Jacobi integral. Curves of zero velocity. Stationary solutions and their stability. The n-body problem. The motion of the centre of mass. Classical integrals.

Section - IV

Perturbation. Osculating orbit. Perturbing forces. Secular and periodic perturbations. Lagrange's planetory equations in terms of pertaining forces and in terms of a perturbed Hamiltonian.

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

Books Recommended:-

1. J.M. A. Danby, Fundamentals of Celestial Mechanics. The MacMillan Company, 1962.
2. E. Finlay, Freundlich, Celestial Mechanics. The MacMillan Company, 1958.
3. Theodore E. Sterne, An Introduction of Celestial Mechanics, Intersciences Publishers. INC., 1960.
4. Arigelo Miele, Flight Mechanics – Vol . 1 - Theory of Flight Paths, Addison-Wesley Publishing Company Inc., 1962.

17MAT24DB5: Stochastic Processes

Time: 03 Hours ***Credits : 4:1:0***

Max Marks : 80

Course Outcomes

Students would be able to:

CO1 Learn about stochastic processes, their classifications and real life applications.

CO2 Understand the concept of Markov chains and to obtain higher transition probabilities.

CO3 Explain various properties of a Poisson process.

CO4 Demonstrate the ideas of birth and death process, immigration-emigration process, renewal process, Regenerative stochastic process, Markov renewal process and semi-Markov process.

CO5 Apply the stochastic theory for modeling real systems/ phenomena and study their implications including reliability of the systems.

Section - I

Stochastic Processes: definition, classification and examples. Markov Chains: definition and examples, Transition matrix, Order of a Markov chain, Markov chain as graphs.

Section - II

Higher transition probabilities, Classification of states and chains. Determination of higher transition probabilities. Poisson Process: Introduction, Postulates, Properties and related distributions.

Section - III

Pure birth process. Birth and death process: Immigration-emigration process, Definitions and simple examples of renewal process in discrete and continuous time, Regenerative stochastic processes, Markov renewal and semi-Markov processes.

Section - IV

Reliability, systems with components in series, Systems with parallel components, k-out-of-n systems, Non-series parallel systems, Systems with mixed mode failures. Standby redundancy: Simple standby system, k-out-of-n standby system.

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. N.T.J. Bailey, Elements of Stochastic Processes
2. J. Medhi, Stochastic Processes, New Age International Publishers
3. E. Balagurusami, Reliability Engineering, Tata McGraw Hill, New Delhi, 1984.
4. L. S. Srinath, Reliability Engineering, Affiliated East West Press, New Delhi, 1991.

17MAT24DB6:Information and Communication Technology

Credits : 3:0:2

Course Outcomes

Students would be able to:

CO1 Learn about various types of computer networks and transmission protocols.

CO2 Implement installation, handling and safe usage of different softwares.

CO3 Understand and analyze the appropriateness of methodologies and technologies for the design and implementation of ICT solutions.

CO4 Know about different type of threats, technologies, ethics and issues related to ICT.

CO5 Demonstrate ICT infrastructure and articulate the relationships and interdependencies between technologies.

Part-A (Theory)

Time : 03 Hours
Max Marks : 60

Section - I

Data, Information and knowledge, ICT – definition, Scope, Importance & Nature of Information & Communication Technology, Applications. Computer System: Classification of digital computers, System hardware, Memory units and auxiliary storage devices, Peripheral devices (Input and output devices), Software, Open source software and open standards. Computer networks, Networking Instruments, Communication devices, Transmission media (Bound links and Unbound links) and Switches.

Section - II

World Wide Web – History, Difference between Internet and www, Search engines. Web Servers: What is a server; Server software, Services provided by servers and their types.
Website: Definition, Portal, Components of website, Building a website, Elements of website, Software to create website. Web pages: Definition, Working, Static and dynamic areas, Website vs. webpage, Web Browser: the tool bar, SSL, Names of various web browsers. Blogs- Definition of blog and bloggers, Advantages and disadvantages of blogging. URL: definition, Elements absolute and relative URL. Protocols: definition, TCP/IP, HTTP, FTP which one to use when and why, Applications and examples.

Section - III

Concept of web services, Email: Definition, Protocols used in email services, Mail account and address, Sending and receiving an email, Features like cc, Bcc, Spam and junk, Email etiquettes-proper structure and layout, Case sensitivity, disclaimer to email, Care with abbreviations and emotions, Chat : Definition, Chat room, Commonly used types of chat.
Video conferencing: definition, Areas of application, Advantages and disadvantages of videoconferencing. e-learning: definition, Benefits, Application areas, E-learning software.
e-shopping: definition, Advantages and dis-advantages, Sites available, Threats and security concerns. e-reservation: definition, Benefits, Application areas, Reservation process, Live and non-livereservation
e-group: definition, Features, Benefits.
Social Networking: definition, Names of various social networking web sites, Merits and demerits, Service providers, Features available, Ethics.

Section - IV

Virus- definition, Types, Virus spread, Protection, Current threats. Worms- definition, Types, Spread, Protection, Current threats. Trojans- definition, Trojan spread, Protection Spyware- definition, Symptoms, Prevention and protection. Malware- definition, Types, Prevention. Spams- definition, Detection and prevention. Hackers and Crackers- definition, Tools available, Types of hacking, Difference between hackersand crackers. Antivirus tools- free and paid tools, Latest tools, There style of working, Importance of regularupdate.

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:

a. Chris Abbott, ICT: Changing Education, Routledge Falmer
b. Wong, M.L. Emily, S.C. Sandy, Tat-heung Choi, and Tsz-ngong Lee, Insights into Innovative Classroom Practices with ICT: Identifying the Impetus for Change, Education Technology & Society.
c. Ann Hatherly, ICT and the greatest Technology: A Teacher Mind, Early Childhood Folio
d. Mary Hayes, David Whitebread, ICT in the Early Years, Open University Press.

Part-B (Practical)

Time: 03 Hours
Max Marks : 40

There will be a separate practical course based on the above theory course (i.e. **17MAT24DB6: Information and Communication Technology)**.