INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-301** Course Title: **Abstract Algebra**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide the basic knowledge about the groups, rings and fields and Galois theory.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic definitions in group theory, characterization of finite groups, subgroups, normal subgroups and quotient groups. Lagrange's theorem.	**8**
2.	Homomorphisms, automorphisms, Cayley's theorem, Permutation groups.	**6**
3.	Sylow's theorems and its applications.	**6**
4.	Basic definitions in ring and field theory, homomorphism, ideals, and quotients rings, maximal ideals.	**6**
5.	Euclidean rings, polynomial rings, polynomial over a rational fields and irreducibility of polynomials.	**6**
6.	Extension fields, roots of polynomials.	**2**
7.	Introduction to Galois theory.	**4**
8.	Galois groups over rationals.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Artin M., "Algebra**",** Prentice Hall India.	**2001**
2.	Fraleigh J. B., "A First Course in Abstract Algebra**",** Narosa Publishing House.	**2004**
3.	Herstein I.N., "Topics in Algebra**",** 2^{nd} Ed., Wiley India **.**	**2006**
4.	Lang,S.**, "**Algebra", Springer.	**2006**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-302** Course Title: **Data Structure**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **EC -101A/EC-101B.**

9. Objective: To provide the concepts of various data structures and their implementation in C++.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Linear Lists:** One and two dimensional arrays, storage allocation, stacks and queues, array representation operations and applications.	8
2.	**Linked Lists:** Linked representation of linear lists, operations on linked lists, circular lists, header lists, doubly linked lists.	8
3.	**Binary Trees:** Definition, array, linked and threaded representations, operations on binary trees and applications.	8
4.	**Sorting:** Selection sort, bubble sort, exchange sort, quick sort, heap sort and merge sort, complexity analysis of sorting techniques.	6
5.	**Searching:** Sequential search, binary search, search trees, hash tables, hashing functions, collision resolution techniques.	6
6.	**Graphs**: Array and linked representation.	6
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Langman Y., Augenstein, M.and Tennenbaum A.M., "Data Structure Using C and C++**",** Prentice Hall of India.	**1998**
2.	Sahni S., "Data Structures Algorithms and Applications in C++**",** McGraw-Hill	**1998**
3.	Dale N., "C++ Plus Data Structures**",** Narosa Publications	**1999**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-303** Course Title: **Data Base Management System**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **EC-101A/EC-101B**

9. Objective: To develop skills to design, access and implement database management system, data warehousing and data mining.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Database Design**: File organization versus database concepts, different models of database, ER model	3
2.	**Relational Model**: Relational operators, relational algebra and calculus, embedded SQL, storage structure in database	5
3.	**Relational Database Design**: Functional dependency, normalization, 1NF, 2NF, 3NF and Boyce-Codd normal form, multi-valued dependency, 4NF, join dependency and 5NF, query processing, SQL and PLSQL.	10
4.	**Transaction Management**: ACID property, concurrency management, recovery management, database security management.	7
5.	**Application Development**: Client-Server architecture, distributed database model, database servers and application servers, internet based applications, database as backend to web tools, ODBC, IDBC.	7
6	**Object Database:** Object data model, new data types, inheritance, object quarry language.	5
7.	**Data Warehousing and Data Mining:** Creating and maintaining a warehouse, views and decision support,ID-3 Algorithm, knowledge discovery , association rules.	5
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Date C.J., "An Introduction to Database System**",** Addison-Wesley Publishing.	**1999**
2.	Desai B.C., "An Introduction to Database Systems**",** Asian Student Edition.	**2002**
3.	Kroenke D.M., "Database Processing**",** Galgotia Publishers.	**1999**
4.	Ramkrishnan R., Gehrke J., "Database Management Systems**",** McGraw-Hill Higher Education.	**2001**
5.	Silberschatz A., Korth H.F. and Sudarshan S., "Database System Concepts**",** Tata McGraw Hill.	**1996**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-304** Course Title: **Number Theory**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce basic concepts of number theory and its applications in public key cryptography.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Divisibility and Euclidean algorithm, extended Euclidean algorithm.	**3**
2.	Congruences, solutions of congruences, Chinese remainder theorem.	**5**
3.	Quadratic residues, quadratic reciprocity, the Jacobi symbol, finite fields.	**5**
4.	Euler's totient function, greatest integer function, arithmetic functions, the Mobius inversion formula, recurrence functions.	**5**
5.	Introduction to public key cryptosystem, elliptic curve cryptography, RSA.	**5**
6.	Primality and factoring, pseudoprimes, the rho method, Fermat factorization and factor bases, continued fraction method, quadratic sieve method.	**5**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Niven I., Zucketman H.S. and Montgomery H. L., "An Introduction to the Theory of Numbers**",** 5th Ed.**,** John Wiley and Sons.	**2000**
2.	Koblitz N., "A Course in Number Theory and Cryptography**",** Springer Verlag.	**1994**
3.	Andrews G.E., "Number Theory", Dover Publication.	**1994**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-305** Course Title: **Optimization**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil.**

9. Objective: To acquaint the students with the theory and techniques of Operations Research.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Different types of OR models.	**2**
2.	Convex sets, graphical method, simplex method, big-M method, two-phase method and revised simplex method, Karmakar Algorithm.	**8**
3.	Duality theory, dual simplex method, sensitivity analysis, parametric linear programming.	**6**
4.	Cutting plane and branch and bound techniques for all integer and mixed integer programming problems.	**5**
5.	Transportation problems , assignment problems and game theory.	**7**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Taha H.A., "Operations Research: An Introduction", 8th.Ed., Prentice Hall of India.	**2006**
2.	Ravindran A., Phillips D.T. and Solberg J.J., "Operations Research: Principles and Practice", 2nd. Ed., John Wiley and Sons.	**2001**
3.	Mital K.V. and Mohan C., "Optimization Methods in System Analysis and Operations Research"**,** New Age India Pvt. Ltd.	**1996**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-306** Course Title: **Real Analysis- I**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **2** **Practical** **0**

4. Relative Weightage**:** **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **MA-101**

9. Objective: To provide the basic properties of functions of a real variable.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Real number system, ordering, bounded sets, order completeness axiom, mathematical induction, well ordering principle; Archimedian property, Dedikind's theorem, complete ordered field, limit point of a set, open and closed sets, Bolzano-Weierstrass theorem.	**5**
2.	Heine-Borel theorem, sequences, Cauchy criterion for convergent sequences, bounded and monotonic sequences, Euler's constant, subsequences, Cauchy sequences, Cauchy's first and second limit theorems, limit superior and limit inferior.	**6**
3.	Sequences and series of real valued functions, their point-wise, absolute and uniform convergence, continuity of the limit (sum) function, differentiation and integration of the sequences and series of functions.	**4**
4.	Limit and continuity, uniform continuity, monotonic functions, functions of bounded variation, absolutely continuous functions, Taylor's theorem (finite form), Lagrange's form of remainders.	**5**
5.	Riemann integration, Darboux's theorem, necessary and sufficient conditions for integrability, functions defined by integrals, fundamental theorem of calculus, mean value theorem of integral calculus.	**8**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Lang S.,"Real and Functional Analysis",Springer-Verlag	**1993**
2.	Rudin W." Principles of Mathematical Analysis**",** McGraw-Hill Book Company	**1976**
3.	Smith A.H., Albrecht W.A., "Fundamental Concepts of Analysis**",** Prentice Hall of India.	**1987**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-307** Course Title: **Probability and Statistics**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide the basic knowledge of probability theory, regression analysis sample distributions and statistical inferences.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic concepts of probability,Bayes Theorem, random variables, distribution functions,	**3**
2.	Hypergeometric, negative binomial, multinomial, normal, exponential, gamma, beta and Weibull distributions.	**6**
3.	Bivariate random variables, joint and marginal distributions, covariance, correlation and regression analysis, transformation of variables.	**5**
4.	Random sampling and sampling distribution, fundamental distributions derived from normal distribution viz. χ^2, t, F and Z (central) distributions.	**4**
5	Statistical inference, Baysian inference, estimation-point and interval, testing of hypothesis, Neyman-Pearson lemma. Some tests based on χ^2, t and F distributions	**10**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Hines W.W., Montgomery D.C., Goldsman D.M. and Borror,C.M.; "Probability and Statistics in Engineering**",**John Wiley.	**2003**
2.	HoggR.V. , Craig A.;"Probability and Statistical Inference**"**, 6^{th}.Ed.,Pearson Education.	**2006**
3.	Miller I.. ,Miller M.; "Mathematical Statistics with Applications**",** Pearson Education.	**2006**
4.	Rohatgi V.K., Mohammed E.S.A.K.,"An introduction to Probability and Statistics**"** 2^{nd}.Ed.,John Wiley**.**	**2000**
5.	Ross S., "First Course in Probability**"**, Pearson Education.	**2006**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-308** Course Title: **Project**

2. Contact Hours: **L: 0** **T: 0** **P: 8**

3. Examination Duration (Hrs.): **Theory** 0 **Practical** 0

4. Relative Weightage**: CWS** 100 **PRS** 0 **MTE** 0 **ETE** 0 **PRE** 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **A course on Data structure and computer programming.**

9. Objective: To provide hands on experience of Data Structure techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Linear List.	**2**
2.	Linked list.	**2**
3.	Binary trees.	**3**
4.	Searching and Sorting.	**3**
5.	Graphs.	**2**
6.	Memory Management.	**2**
	Total	**14**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Sahni S., "Data Structures Algorithms and Applications in C++", McGraw Hill	**2000**
2.	Tanenbaum A.M., "Data Structure Using C and C++", Prentice-Hall	**1999**
3.	Online Manual IITR Server	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-501** Course Title: **Theory of Ordinary Differential Equations**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **MA-101 or equivalent .**

9. Objective: To provide theoretical concepts of Ordinary differential equations, boundary value and eigen value problems autonomous systems and their stability.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Existence, uniqueness and continuation of solutions of a differential equation and system of differential equations.	**7**
2.	Linear systems, properties of homogeneous and non-homogeneous systems, behaviour of solutions of nth order linear homogeneous equations.	**7**
3.	Power series solution of second order homogeneous equations, ordinary points, regular singular points, solution of Gauss hypergeometric equations, Hermite and Chebyshev polynomials.	**10**
4.	Boundary value problems for second order differential equations,Green's function and its applications.	**4**
5.	Eigen value problems, self adjoint form, Sturm –Liouvile problem	**4**
6.	Autonomous systems, phase plane and its phenomenon, critical points and stability for linear and non linear systems, Liapunov's direct method, periodic solutions, the Poincare-Bendixson theorem.	**10**

	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Coddington E.A., "Ordinary Differential Equations**",** Tata McGraw Hill	**2002**
2.	Joshi,M.C., "Ordinary Differential Equations(Modern Perspective**)",** Narosa Publishing House	**2006**
3.	Perko,L., "Differential Equations and Dynamical Systems**"**, Springer	**2001**
4.	Simmons G.F., "Ordinary Differential Equations with Applications**",** Tata McGraw Hill	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-502** Course Title: **Advanced Numerical Analysis**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **MA-202M or its equivalent.**

9. Objective: To provide knowledge about advanced numerical methods for solving partial differential equations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Computations of Eigen Values of a Matrix:** Power method for dominant, sub-dominant and smallest eigen-values, Jacobi, Givens and Householder methods for symmetric matrices, LR and QR methods.	8
2.	**Finite Differences:** Review of finite difference operators, finite difference methods.	2
3.	**Elliptic PDE:** Five point formulae for Laplacian, replacement for Neumann's boundary conditions, curved boundaries, solution on a rectangular domain, block tri-diagonal form and its solution using method of Hackney.	5
4.	**Parabolic PDE:** Concept of compatibility, convergence and stability, Explicit, fully implicit, Crank-Nicholson, du-Fort and Frankel scheme, ADI methods to solve two-dimensional equations.	5
5.	**Hyperbolic PDE:** Solution of hyperbolic equations using rectangular and characteristic grids.	5
6.	**Weighted Residuals:** Collocation, least squares and Galerkin's methods.	3
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Gerald C.F., **"**Applied Numerical Analysis", Addison-Wesley Publishing	**2002**
2.	Smith G.D., "Numerical Solution of Partial Differential Equations", Oxford University Press.	**2001**
3.	Jain M.K., "Numerical Solution of Differential Equations"**,** John Wiley.	**1991**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-503** Course Title: **Real Analysis -II**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**: CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite: **MA-306 or equivalent .**

9. Objective: To impart the knowledge of advanced topics in theory of real functions and metric space properties

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	Functions of several variables, invertible functions, Jacobian of a transformation, inverse mapping theorem, implicit function theorem.	**6**
2.	Riemann Stieltje's integrals, existence and properties of the integrals, fundamental theorem of calculus, integration of sequences and series of functions, first and second mean value theorems.	**8**
3.	Introduction to the properties of general measurable and measure spaces, Borel algebras, complete measure.	**2**
4.	Lebesgue outer measure and measure on the real line, measurable sets and their properties, translation invariance and completeness of Lebeasgue measure, Lebesgue integral of a simple function, comparision of Lebesgue and Riemann integrals.	**5**
5.	Metric spaces, open and closed sets, interior, closure and limit points of a set, subspaces, continuous functions on metric spaces, convergence in a metric space, complete metric spaces.	**7**

Total	**28**

11. Suggested Books:

S. No.	Name of the Books / Authors / Publisher	Year of Publication
1.	Apostol, T.M., "Mathematical Analysis**"**, Addison-Wesley	**1986**
2.	Apostol, T.M., "Calculus, Vol. I & II", John Wiley & Sons.	**1990**
3.	Royden, H.L., "Real Analysis", Collier McMillan.	**1988**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-504** Course Title: **Theory of Elasticity**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the fundamentals of mathematical theory of elasticity and its applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Analysis of Stress and Strain:** Analysis of stress and infinitesimal strain, transformation equations, principal directions, equations of equilibrium, compatibility equations.	**14**
2.	**Equations of Elasticity:** Hooke's laws, generalised Hooke's law, elastic constants for isotropic media, equations of elasticity, Saint-Venant's principle, strain energy for isotropic media.	**4**
3.	**Plane Stresses and Strain:** Plane strain, plane stress and generalized plane stress, Airy's stress function.	**4**
4.	**Applications:** Pure bending of a light prismatic bar, torsion of a circular shaft, light cantilever loaded at one end, uniformly loaded beam supported at the two ends.	**6**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Mital K.V., "Theory of Elasticity"**,** Pothishala Pvt. Ltd.	**1970**
2.	Filonenko-Borodich M., "Theory of Elasticity", Peace Publishers.	**2002**
3.	Fung Y.C., "Foundations of Solid Mechanics", Prentice Hall of India Pvt. Ltd.	**1968**
4.	Varadan T.K. and Bhaskar K., "Analysis of Plates", Narosa Publishing House.	**2005**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-505** Course Title: **Mechanics-II**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **MA-203 M or equivalent.**

9. Objective: To impart the knowledge of advanced topics of in statics and dynamics and their applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Statics:** Condition of equilibrium for a system of forces, the general finite and infinitesimal displacements of a rigid body.	4
	Work, potential energy and virtual work, stable and unstable equilibrium.	4
2.	**Dynamics:** Equations of motion, general motion of a rigid body, momental ellipsoid and principal axes.	4
	Kinetic energy and angular momentum of a rigid body, principles of energy & stress momentum.	5
	Moving frames of reference, coriolis force, simple dynamical systems.	5
	Lagrange & Hamilton equations, Hamilton's principle & its applications, small oscillations.	6

	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Synge J.L. ,Griffith B.A., "Principles of Mechanics", Tata McGraw Hill.	**1987**
2.	Beer F.P., Johnston E.R.,Eisenberg E.R. and Clausen W.E., "Vector Mechanics (Vol. I & II) Statics & Dynamics"**,** Tata McGraw Hill	**2005**
3.	Shames I., "Engineering. Mechanics", Pearson education.	**2005**
4.	Goldstein H., "Classical Mechanics", Addison-Wesley Press.	**2006**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-506** Course Title: **Theory of Partial Differential Equations**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To equip the students with the analytical methods for solving different types of partial differential equations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Analytical Solutions:** Quasi-linear first order equations, method of Lagrange, Cauchy problems, complete integrals, Charpit's method, classification of second order quasi-linear equation, reduction to normal form.	**8**
2.	**Elliptic equations:** Laplace equation in cartesian, polar, spherical and cylindrical coordinates and its solution by Fourier series method, Poisson equation in 2D.	**8**
3.	**Hyperbolic Equation:** One and two dimensional wave equation, solution by method of characteristics and Fourier series method.	**7**
4.	**Parabolic Equation:** Solution of homogeneous and non-homogeneous diffusion equation (1D).	**5**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Dennemeyer R., "Introduction to Partial Differential Equations and Boundary Value Problems", Tata McGraw Hill.	**1968**
2.	Snedden I.N., "Elements of Partial Differential Equations", Courier Dover Publications.	**2006**
3.	McOwen," Partial Differential Equations", 2nd Ed., Pearson Education.	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-507** Course Title: **General Topology**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **2** **Practical** **0**

4. Relative Weightage**:** **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide the basic knowledge of topological properties such as connectedness, compactness, separation axioms and metrization theorem.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Topological spaces, neighbourhoods, closure, interior and boundary points, bases and sub-bases, countability axioms, order topology, product topology.	**6**
2.	Continuous functions, metric topology, quotient topology, connected spaces, components and path components, local connectedness, compact spaces, sequential compactness, Lebesgue number lemma, local compactness, paracompact Spaces.	**10**
3.	Separation axioms, T_1, Hausdorff, regular, completely regular and normal spaces and their properties, Tietz extension theorem.	**6**
4.	Urysohn's lemma, Urysohn's metrization theorem, Tychonoff's theorem, Stone-Cech compactification, Ascoli's Theorem.	**6**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Munkers J. R., "Topology, A First Course", Prentice-Hall of India.	**1988**
2.	Simmons G.F., "Introduction to Topology and Modern Analysis", McGraw-Hill Company.	**2004**
3.	Wilanski,A., "Topology for Analysists"**,** Kluwer Academics	**2001**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-508** Course Title: **Non-linear Programmimng**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**: CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **MA-305 or its equivalent.**

9. Objective: To acquaint the students with advanced techniques used in nonlinear, geometric and dynamic programming .

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Graphical Method and Linear Programming Method for Rectangular Games**.	5
2.	**Nonlinear Programming:** Convex functions, Kuhn Tucker theory, convex quadratic programming, Wolfe's, Beale and complementary pivot algorithm, separable programming.	11
3.	**Geometric Programming:** Problems with positive co-efficients upto one degree of difficulty, generalized method for positive and negative methods.	6
4.	**Dynamic Programming:** Discrete and continuous dynamic programming, Bellman's principle,simple illustrations.	6
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Taha H.A., "Operations Research: An Introduction" 7th Ed., MacMillan Pub Co.	**2003**
2.	Ravindran A, Phillips D.T. and Solberg J.J., "Operations Research: Principles and Practice", , 2nd. Ed. John Wiley and Sons.	**2001**
3.	Mital K.V. , Mohan C., "Optimization Methods in System Analysis and Operations Research", New Age India Pvt. Ltd.	**1996**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-509** Course Title: **Mathematical Methods**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide knowledge of essential mathematical tools applied in solving initial and boundary value problem.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review:** Fourier Transform (FT), Fourier integral theorems and Laplace transform, inversion of Laplace transform by residue method.	4
2.	**Applications of Integral Transforms.**	4
3.	**Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT):** Definition and elementary properties, convolution theorems, relation of DFT with FFT and FT.	6
4.	**Integral Equations:** Linear integral equation of first and second kind. conversion of n^{th} order differential equation into integral equations, solution by the successive approximation, Neumann series and method of resolvent kernel, Hilbert transform method singular equations.	6
5.	**Calculus of Variations:** Functionals and their Gauteaux derivative's, Euler equations, cases of one and several independent variables, initial value problems, application to dynamical problems, Weierstrass's sufficiency condition for weak and strong extrema.	8
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Hildebrand F.B., "Methods of Applied Mathematics", Courier Dover Publications.	**1992**
2.	Nzih G.O., "Discrete Fourier Transform and its Applications**"**, Elsevier Publishing Company.	**1978**
3.	Sagan H., "Introduction to Calculus of Variations", Courier Dover Publications.	**1992**
4.	Elsgolts L., "Differential Equations and Calculus of Variations", University Press of the Pacific.	**2003**
5	Gelfand M. and Fomin S.V., "Calculus of Variations", Courier Dover Publications.	**2000**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-510** Course Title: **Functional Analysis**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **2** **Practical** **0**

4. Relative Weightage**:** **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **MA-503, MA-507**

9. Objective: To provide the basic knowledge of the concepts of normed linear spaces, inner product spaces , continuous linear maps and uniform boundedness..

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Normed Linear Spaces (NLS), convergence and absolute convergence in NLS, Banach spaces.	**5**
2.	Inner product spaces, Hilbert spaces, direct sum, convex sets, projection theorems, Bessel's inequality, Parseval's identity, Cauchy Schwarz inequality.	**6**
3.	Continuous linear map, norm of a linear map, dual space, adjoint operators on Hilbert space, Riesz-representation theorem.	**6**
4.	Positive operators, self adjoint, normal, unitary operators and their properties.	**4**
5.	Hahn-Banach theorem, uniform boundedness theorem, closed-graph and open mapping theorems.	**7**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Simmons G.F., "Introduction to Topology and Modern Analysis", McGraw Hill.	**2004**
2.	Debnath L.K. , Mikusinski P., "Introduction to Hilbert Spaces with Applications"**,** Academic Press.	**2000**
3.	Ponnusamy S.,"Foundation of Functional Analysis", Narosa Publications.	**2002**
4.	Jain P.K., Ahuja, O.P. and Ahmad, K., "Functional Analysis", New Age International Publishers.	**1995**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-601** Course Title: **Multivariate Techniques**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **2** **Practical** **0**

4. Relative Weightage**:** **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **MA-307 or its equivalent.**

9. Objective: To introduce two and multiple variable regression models, residual analysis and analysis of variance..

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	Empirical problem solving, measurement systems.	**3**
2.	Causal relationships, statistical models.	**3**
3.	Linear models, two variable and multiple variable regression models, assumptions, methods for estimation of model, least square, minimum variance, best fit solutions, measure for quality of linear model, standard error.	**8**
4.	Inference about model: Estimation, confidence intervals and tests of significance for parameters of model.	**4**
5.	Regression diagnostics, residual analysis, collinearity.	**4**
6.	Analysis of variance: Basic concepts, Gauss Markoff theorem, One way classification, comparison of more than two means, statistical model and analysis for one way layout, two way classification, statistical model and analysis for two way layout, analysis of variance using linear models.	**6**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Miller I., Miller M. and Freund,"Mathematical Statistics with Application"**,** 7th Ed**,** Pearson Education.	**2006**
2.	Hogg R.V., Craig A., "Introduction to Mathematical Statistics", 5th Ed.**,** Pearson Education.	**2006**
3.	Kleinbaun D.G., Kupper L.L., Muller K.E., Nizam A., "Applied Regression Analysis and other Multivariable Methods", 3rd Ed. , Duxbury Press CA**.**	**1998**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-602** Course Title: **Seminar**

2. Contact Hours: **L: 0** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 0 **Practical** 0

4. Relative Weightage**: CWS** 100 **PRS** 0 **MTE** 0 **ETE** 0 **PRE** 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: DEC**

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8. Pre-requisite**:** **Nil**

9. Objective: To inspire the students for self study.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Self study	**8**
	Total	

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.		
2.		
3.		
4.		

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-603** Course Title: **Fluid Dynamics**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To introducethe general equations of motion inviscid case , stream functions and vorticity equation .

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Lagrangian and Eulerian descriptions, continuity of mass flow, circulation, rotation and irrotational flows, boundary surface, streamlines, path lines, steak lines, vorticity.	**6**
2.	General equations of motion inviscid case, Bernoulli's theorem, compressible and incompressible flows, Kelvin's theorem, constancy of circulation.	**4**
3.	Stream function, complex-potential, sources, sinks and doublets, circle theorem, method of images, theorem of Blasius, Stokes stream function, motion of a sphere.	**7**
4.	Helmholtz's vorticity equation, vortex filaments, vortex pair.	**2**
5.	Navier-Stokes equations, dissipation of energy, diffusion of vorticity, steady flow between two infinite parallel plates, through a circular pipe (Hagen-Poiseuille flow), flow between two co-axial cylinders, flow between two con-centric rotating cylinders, principle of dynamical similarity, the energy	**9**

	equation .	
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Yuan S.W., "Foundation of Fluid Mechanics", 3rd Ed.**,** Prentice Hall.	**1976**
2.	Batechelor G.K., "An Introduction to Fluid Dynamics", Cambridge.	**1997**
3.	Schliting H. , Gersten K., "Boundary Layer Theory", Springer.	**2004**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-605** Course Title: **Mathematical Modeling**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **MA-501/MA-506.**

9. Objective: To impart essential concepts of growth and decay models, discrete model system of differential equations and simulation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Mathematical modeling, types of models, characteristics of mathematical models, framework of modeling, dimensional analysis.	2
2.	**Growth and Decay Models**: Cell growth, drug absorption, water heating and cooling, mixing problems, logistic growth model.	6
3.	**Discrete Models**: Simple growth model, cobwebbing, tumor cell growth model, fishery management models, delay models.	4
4.	**System of Equations:** Two species population models, epidemic models, models for economics and finance and stability analysis.	10
5.	**Simulation:** Types of simulation, numerical simulation,simple case studies of queuing and inventory problems.	6
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Burghes D.N., Borie, M.S., "Modelling with Differential Equations", Ellis Honowood Ltd.	**1982**
2.	Beltrami E., "Mathematics for Dynamic Modeling", Academic Press.	**1987**
3.	Murray J.D., "Mathematical Biology: An Introduction", Springer.	**1989**
4.	Giordano F.R., "A First Course in Mathematical Modeling", Brooks/Cole Publishing Company.	**1997**
5.	Barnes B , Fulford G.R., "Mathematical Modeling with Case Studies", Taylor and Francis.	**2002**
6.	Law A.N., Kelton W.D., "Simulation Modelling and Analysis", McGraw-Hill Education.	**1991**

List of Departmental Electives

MA-321	Course Title:	**Graph Theory**
MA-322	Course Title:	**Fuzzy Set Theory**
MA-323	Course Title:	**Control Theory**
MA-324	Course Title:	**Discrete Mathematics**
MA-326	Course Title:	**Biomathematics**
MA-521	Course Title:	**Tensors and Differential Geometry**
MA-522	Course Title:	**Complex Analysis II**
MA-523	Course Title:	**Computer Graphics**
MA-525	Course Title:	**Image Processing**
MA-526	Course Title:	**Soft Computing**
MA-527	Course Title:	**Optimal Control Theory**
MA-528	Course Title:	**Robotics and control**
MA-529	Course Title:	**Computer Vision**
MA-530	Course Title:	**Statistical Inference**
MA-531	Course Title:	**Cryptography**
MA-532	Course Title:	**Applied Graph Theory**
MA-533	Course Title:	**Software Engineering**
MA-621	Course Title:	**Approximation theory**
MA-622	Course Title:	**Wavelet Theory**
MA-623	Course Title**:**	**Dynamical Systems**
MA-624	Course Title:	**Operations Research-III**
MA-625	Course Title**:**	**Finite Element Methods**
MA-626	Course Title**:**	**Advanced Functional Analysis**
MA-627	Course Title:	**Theory of Vibrations**
MA-628	Course Title:	**Computational Fluid Dynamics**
MA-629	Course Title:	**Hydrodynamic Stability**
MA-630	Course Title:	**Introduction to Fracture Mechanics**
MA-631	Course Title**:**	**Advanced Fluid Dynamics**
MA-632	Course Title:	**Advanced Mathematical Modelling**
MA-633	Course Title**:**	**Lebesgue Measure & Integration**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-321** Course Title: **Graph Theory**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart basic knowledge and concepts of graph theory for its use in various practical applications in science and engineering.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Graphs:** Definition of a graph, simple graph, degree of a vertex, regular graph, bipartite graphs, sub graphs, complete graph, complement of a graph, operations of graphs, isomorphism, digraphs and relations.	**6**
2.	**Paths and Circuits:** Walks, paths and circuits, connectedness of a graph, disconnected graphs and their components, Euler graphs, Hamiltonian paths and circuits, existence theorem for Eulerian and Hamiltonian graphs, traveling salesman problem.	**4**
3.	**Trees and Fundamental Circuits:** Trees and their properties, distance and centre in a tree and in a graph, rooted and binary trees, spanning trees, fundamental circuits, breadth first and depth first search.	**4**
4.	**Cut-sets and Cut-vertices:** Cut-sets and their properties, fundamental circuits and cut-sets, connectivity and separability, network flows, 1-isomorphism, 2-isomorphism.	**4**
5.	**Planar and Dual graphs:** Planar graphs, Euler's formula, Kuratowski's graphs, detection of planarity, geometric dual, combinatorial dual.	**4**
6.	**Matrix Representation of Graphs:** Incidence matrix and its sub matrices,	**6**

	reduced incidence matrix, circuit matrix, fundamental circuit matrix, cut set matrix, fundamental cut set matrix, path matrix, adjacency matrix of a graph and of digraph.	
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Deo N., "Graph Theory with Applications to Engineering and Computer Science", Prentice Hall of India.	**2004**
2.	Clark J., Holton D.A., "A First Look at Graph Theory", Allied Publishers Ltd.	**1995**
3.	West D.B., "Introduction to Graph Theory", Pearson Education.	**2002**
4.	Mott J.L., Kandel A, and Baker T.P., "Discrete Mathematics for Computer Scientists and Mathematicians", Prentice Hall of India.	**2001**
5.	Reinhard D., "Graph Theory", Springer International Edition..	**2004**
6.	Agnarsson G., Greenlaw R., "Graph Theory : Modeling, Applications, and Algorithms", Pearson Education.	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-322** Course Title: **Fuzzy Set Theory and its Application**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the basic concepts of fuzzy-set theory, fuzzy logic, approximate reasoning and their various applications in decision making.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic concepts, fuzzy sets, membership functions.	**4**
2.	Operations on fuzzy sets, cartesian product, algebraic sum, bounded sum, bounded difference and algebraic product of fuzzy sets, m-th power of a fuzzy set, set theoretic operations, t-norm and t-conorms.	**6**
3.	Fuzzy arithmetic, fuzzy numbers, fuzzy equations.	**6**
4.	Fuzzy relations and graphs, fuzzy logic, approximate reasoning.	**7**
5.	Fuzzy decision making and applications.	**5**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Klir G.J., Yuan Bo, "Fuzzy sets and Fuzzy Logic: Theory and Applications", Prentice Hall of India.	**2003**
2.	Zimmermann H.J., "Fuzzy Set Theory and its Applications",2nd Ed., Allied Publishers Ltd.	**1996**
3.	Klir G.J., Folger T.A., "Fuzzy Sets, Uncertainty and Information", Prentice Hall of India.	**2000**

4.	Pedrycz W., Comide F., “An Introduction to Fuzzy Sets, Analysis and Design”, Prentice Hall of India.	**2005**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-323** Course Title: **Mathematical Control Theory**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**: Nil**

9. Objective: To introduce the basic concepts of control theory in control system and its Stability

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Mathematical methods of simple dynamical and control systems, open loop and closed loop systems, block diagram representation of a system.	**3**
2.	**Control Systems:** State space representation of a system, state transition matrix, solution of linear systems, companion form, controllability and observability, duality theorem, computation of optimal control, transfer function methods for linear systems, state observers and controllers' design.	**10**
3.	**Stability:** Stability of linear systems, stabilizability by state feedback using companion forms, Routh criterion, stability analysis using Nyquist plot, nonlinear systems, linearization techniques,limit cycles.	**9**
4.	**Lyapunov theorems :** Lyapunov theorems for stability of nonlinear systems, construction of Lyapunov functions.	**6**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Stephen B.,"Introduction to Mathematical Control Theory", Oxford Press.	**1975**
2.	Datta B.N., "Numerical Methods for Linear Control Systems", Academic Press Elsevier.	**2005**
3.	Frank, M. C. , Charles A.D., "Linear System Theory", Springer Verlag.	**1991**
4.	Ogata K.,"Modern Control Engineering",4th Ed.,Pearson Education.	**2008**
5.	Ogata K., "State Space Analysis of Control Systems", Prentice Hall.	**1967**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-324** Course Title: **Discrete Mathematics**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide the basic knowledge of Boolean algebra, relations, number theory , graphs and finite state machines

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Combinatorial tolls, induction, comparing and estimating numbers, inclusion-exclusion principle, Pigeon-hole principle.	**04**
2.	Relations and their properties, equivalence relations and partitions, partial ordering and lattices.	**03**
3.	Boolean algebra and boolean functions with applications.	**03**
4.	Recurrence relations and recursive algorithms.	**02**
5.	Number theory, divisibility, prime factorization, Fermat's first theorem.	**03**
6.	Congruences, Euclidean algorithms and Chinese remainder theorem.	**03**
7.	Graphs, paths, cycles, trees. Hamiltonian cycles, Euler circuits, planar Graphs.	**03**
8.	Flows, connectivity and matching.	**03**
9.	Finite state machines and its representations.	**04**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Liu C.L., "Elements of Discrete Mathematics", Tata McGraw Hill.	**2000**
2.	Lovasz L., Pelikan J. and Gombi V. K., "Discrete Mathematics", Springer International Ed.	**2003**
3.	Kolman B., Busby R.C. and Ross S.C., "Discrete Mathematical Structures", 5^{th} Ed, Pearson Education.	**2005**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-521** Course Title: **Tensors and Differential Geometry**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce to the basic concepts of tensor algebra, tensor calculus and theory of curves and surfaces in the neighborhood of a point..

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Tensor Analysis:** Summation convention and indicial notation, coordinate transformation and its Jacobian, contravariant and covariant vector, tensors of various types, algebra of tensors and contraction.	3
	Metric convention and 3-index Christoffel symbols, parallel propagation of vector, covariant derivative and intrinsic derivative. curvature tensor and its properties, curl, divergence and Laplacian operators in tensor form, tensor representation of some equations of mathematical physics, physical components.	5
2.	**Curves:** Definition of space curves, arc length, tangent, normal, binormal, Frenet's formulae, curvature and torsion.	3
	Order of contact, osculating circle and sphere, fundamental existence theorem for space curves, helices, evolutes and involutes.	7
3.	**Surfaces:** Definition of a surface, tangent plane, normal, surfaces of revolution, concoid and helicoids, envelopes and developable surfaces.	3

	Metric and direction coefficients, second fundamental form, Meusnier's theorem, Euler's theorem and Dupin's indicatrix. Gaussian curvature, normal curvature, geodesic curvature, Liouville's formulae, differential equation of a geodesic, fundamental theorem on surfaces.	**7**
	Total	**28**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Struik D.J.," Lectures on Classical Differential Geometry", 2nd Ed., Addison-Wesley.	**1988**
2.	Somasundaram D., "Differential Geometry: A First Course", Narosa.	**2008**
3.	De U.C., Shaikh A.A. and Sengupta J., "Tensor Calculus", Narosa.	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-522** Course Title: **Advanced Complex Analysis**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-201M or its equivalent.**

9. Objective: To impart the advance knowledge of functions of complex variable and analytic function theory**.**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Analytic Functions**: Zeroes of analytic functions, Jensen's theorem, meromorphic functions, their zeroes and poles, Poisson-Jensen's formula. The argument principle, Rouche's theorem, harmonic functions, the Drichlet's problem.	**7**
2.	**Conformal Transformations**: Elementary conformal mappings, bilinear transformation, Schwarz-Christoffel transformations.	**5**
3.	**Power Series**: Power series with finite radius of convergence, position of singularity, convergence of the series and regularity of the functions, asymptotic behaviour near the circle of convergence, Abel's and Littlewood's theorems.	**6**
4.	**Analytic Continuation**: Definition and uniqueness of analytic continuation, standard method of analytic continuation using power series, the principle of reflection, Hadamard multiplication theorem, functions with natural boundaries.	**4**
5.	**Maximum Modulus**: Maximum modulus theorem, Schwarz lemma, Hadamard's three circles theorem, convex functions, the mean values of	**6**

	analytic functions and their properties, theorems of Phragman and Lindelof.	
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Ahlfors L.V.,"Complex Analysis", McGraw Hill.	**1979**
2.	Rudin W., "Real and Complex Analysis", McGrawHill.	**1987**
3.	Lang S.,"Complex Analysis", Springer International Edition.	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-523** Course Title: **Computer Graphics**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the application of mathematical for drawing and visualize various curves and surfaces on a computer.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to basic techniques, graphic devices.	**2**
2.	Point plotting techniques, screen coordinate system, line drawing algorithms, circle generation.	**4**
3.	Two dimensional transformations-translation, rotation and scaling with matrix representations.	**4**
4.	Clipping and windowing.	**4**
5.	Three dimensional transformations and their matrix representation.	**4**
6.	Curves and Surfaces, Bezier methods, B-spline.	**6**
7.	Hidden line and surface elimination.	**2**
8.	Introduction to computer animation.	**2**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Foley J. D., Dam A. V., “Computer Graphics: Principles and Practice”, Pearson Education Asia.	**2001**
2.	Rogers D. F, Adams J. A.,“Mathematical Elements for Computer Graphics” , Tata McGraw Hill.	**2002**
3.	Hearn D., Baker M. P., “Computer Graphics”, Prentice Hall.	**2002**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-525** Course Title: **Image Processing**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil.**

9. Objective: To introduce the concepts of Image Processing techniques such as geometry-stereo vision, image enhancements and restoration

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to image processing, digital images-the eye, brightness, image sampling, neighbors of pixels, distance.	**3**
2.	Multiview geometry-stereo vision, the correspondence problem, algorithms for stereo matching.	**3**
3.	Spatial image enhancements-transformations, negative, log, power, histogram, subtraction, averaging, smoothing, Laplacian.	**4**
4.	Frequency domain image enhancements, 1D and 2D Fourier transforms and their inverses ,lowpass and highpass filtering, unsharp and high-boost, use of FT, FFT.	**6**
5.	Image restoration–Noise, mean filter, median, min, max, midpoint, adaptive filters and frequency domain.	**4**
6.	Color image processing- RGB, CMY, CMYK, HSI, operations on color images.	**4**
7.	Applications of wavelets in image processing.	**4**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Gonzalez R.C. , Woods R.E.," Digital Image Processing", Addison-Wesley.	**2004**
2.	Forsyth D.A., Ponce J.,"Computer Vision: A Modern Approach", Prentice Hall.	**2003**
3.	Shalkoff R.J., John, "Digital Image Processing and Computer-Vision", Wiley and Sons.	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-526** Course Title: **Soft Computing Techniques**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart knowledge of soft computing techniques of neural networks, fuzzy set theory ,genetic algorithms.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Neural Networks:** Fundamentals, neural network, architectures, feedforward networks, backpropagation networks.	7
2.	**Fuzzy Set Theory:** Fuzzy logic, fuzzy systems.	5
3.	**Genetic Algorithms:** Encoding, fitness function, reproduction, crossover, mutation.	8
4.	**Particle Swarm Optimization:** Introduction and basic concepts.	2
5.	**Ant Colony Optimization:** Introduction and basic concepts.	2
6.	**Hybrid Systems:** Genetic algorithm based backpropagation network, fuzzy–back propagation, fuzzy logic controlled genetic algorithms, case studies.	4
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Rajasekaran S. , Vijayalakshmi P.G.A., "Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications", Prentice Hall of India.	**2003**
2.	Jang J.S.R. , Sun C.T. and Mizutani E., "Neuro – Fuzzy and Soft Computing", Prentice Hall of India.	**2002**
3.	Tettamanzi A. ,Tomassini M., "Soft Computing: Integrating Evolutionary, Neural, and Fuzzy Systems", Springer Verlag.	**2001**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-527** Course Title: **Optimal Control Theory**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **2** **Practical** **0**

4. Relative Weightage**:** **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits**:** **3** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the variational and dynamic programming approach for solving optimal control problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Control Problems:** General problem of the optimal control, problem formulation for economic growth, resource depletion, exploited populations, advertising policies, rocket trajectories servo problem,.	**7**
2.	**Variational Method:** Necessary conditions for optimal control, Hamiltonian, Pontryagin's principle for continuous and for bounded and discontinuous controls, state inequality constraints, switching curves, trasversality conditions, singular integrals in optimal control problems.	**12**
3.	**Dynamic Programming Method:** Optimal control law, principle of optimality and its application to decision making in optimal control problems, computational methods for solving optimal control problems.	**9**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Burghes D.N. ,Graham A. "Introduction to Control Theory Including Optimal Control", John Wiley & Sons.	**1980**
2.	Canon MD., Culum J.R., CC and Polak E., "Theory of Optimal Control & Mathematical Programming", McGraw-Hill.	**1970**
3.	Kirk D.E, "Optimal Control Theory-An Introduction," Prentice Hall.	**1970**
4.	Lee E.G. , Markus L., "Foundations of Optimal Control Theory", John Wiley & Sons.	**1967**
5.	Hull D.G., "Optimal Control Theory", Springer.	**2005**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-528** Course Title: **Robotics and control**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the concepts of robotic vision and control.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, simple planar manipulators and its kinematics	**2**
2.	Coordinate frames, translation, rotation and homogeneous transformation matrices, change of frames.	**3**
3.	D-H algorithm, joint and link parameters, arm matrices, kinematic equation of manipulators, inverse kinematic solutions, work space analysis, path planning, biped manipulators.	**10**
4.	Differential transformation, manipulator Jacobian, dynamic equation of manipulators.	**6**
5.	Stability and control of manipulators.	**4**
6.	Vision -stereo vision and visual servo control for tracking.	**3**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Schilling R.," Fundamentals of Robotics, Analysis and Control", Prentice Hall.	**2000**
2.	Paul R., "Introduction to Robot Manipulators: Mathematics, and Programming", MIT Press.	**1981**
3.	Craige J.J., Introduction to Robotics: Mechanics and Control, Addison-Wesley.	**1989**
4.	Fu K.S., Gouzalez R.C. and Lee C.S.G, "Robotics: Control, Sensing, Vision and Intelligence", Mc-Graw Hill.	**1987**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-529** Course Title: **Computer Vision**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **CE-201.**

9. Objective: To introduce the basic concepts of Computer Vision such as early, mid-level, high – level visions and their applications.

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10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Image Formation and Image Models:** Cameras, geometric camera models, geometric camera calibration radiometry – measuring light sources, shadows and shading color.	**4**
2.	**Early Vision:** Just one image, linear filters edge detection texture, multiple images, the geometry of multiple views stereopsis, affine structure from motion, projective structure from motion.	**8**
3.	**Mid-Level Vision:** Segmentation by clustering, segmentation by fitting a model, segmentation and fitting using probabilistic methods, tracking with linear dynamic models.	**4**
4.	**High-Level Vision:** Geometric methods, model-based vision, smooth surfaces and their outlines, aspect graphs range data, probabilistic and inferential methods, finding templates using classifiers, recognition by relations between templates geometric, templates from spatial relations.	**8**
5.	**Applications:** Digital libraries ,image-based rendering.	**4**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Forsyth D.A., Ponce J., "Computer Vision: A Modern Approach", Prentice Hall.	**2003**
2.	Gonzalez R.C. ,Woods R.E.," Digital Image Processing", Addision-Wesley.	**2004**
3.	Shirai Y.," Three Dimensional Computer Vision", Springer Verlag.	**2002**
4.	Shalkoff R.J., "Digital Image Processing and Computer-Vision" John Wiley and Sons.	**2000**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-530** Course Title: **Statistical Inference**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-307 or its equivalent.**

9. Objective: To acquaint the students with the theory of decision problem and different estimators and various testing hypothesis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**General Decision Problem:** Loss function, risk function, randomized decision rules, admissibility, Bayes' and minimax decision rules, sequential decision rules.	8
2.	**Theory of Estimation:** Unbiasedness and sufficiency of estimators, factorization criterion, minimum variance estimation, Cramer-Rao bound and its generalization, completeness and bounded completeness, Rao Blackwell theorem, Existence of UMVUE estimators.	12
3.	**Testing of Hypothesis:** Critical region and power, Neyman– Pearson lemma, likelihood ratio principle, uniformly most powerful tests, sequential probability ratio test.	8
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Rao C.R., "Linear Statistical Inference and its Applications', Wiley Eastern Ltd.	**2001**
2.	Ferguson T., "Mathematical Statistics –A Decision Theoretic Approach", John Wiley and Sons.	**1967**
3.	Berger J.O., "Statistical Decision Theory", Springer – Verlag.	**1985**
4.	Lehman E.L., "Point Estimation", John Wiley and Sons.	**1984**
5.	Casella G., Berger R.L., Statistical Inference. 2nd Ed., Duxbury Press.	**2002**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-531** Course Title: **Cryptography**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-301 and MA-307 or equivalent.**

9. Objective: To give the mathematical background of Cryptography and to introduce the concepts of symmetric and public key cryptography.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Mathematical Background:** Complexity theory, modular arithmetic, finite fields.	6
2.	**Symmetric-key Encryption:** Introduction to stream ciphers, design of LFSR based stream ciphers, block ciphers, substitution-permutation networks (SPN), linear attack on SPN, introduction to DES and AES.	6
3.	**Cryptographic Hash Functions:** Security of hash functions, the random oracle model, iterated hash functions, the Merkle Damgard construction, message authentication codes , probabilistic signatures.	10
4.	**Public-key Cryptography:** The RSA cryptosystem and factoring integers, attacks on RSA, digital signatures, the secure application of RSA encryption.	6
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Stinson D.R., “Cryptography Theory and Practice”, Chapman & Hall/CRC.	**2002**
2.	Hans D., Helmut K., “Introduction to Cryptography, Principles and Applications”, Springer.	**2002**
3.	Schneier B., “Applied Cryptography”, Wiley.	**1996**
4.	Stallings W., “Cryptography and Network Security”, Pearson Education.	**2005**
5.	Koblitz N., “A Course in Number Theory and Cryptography”, Springer.	**1994**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-532** Course Title: **Applied Graph Theory**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Both** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-321 or its equivalent.**

9. Objective: To introduce the graph theoretical algorithms and their implementation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Algorithms**	3
2.	**Graph Theoretic Algorithms and Computer Programs:** Algorithms to determine connectedness components, spanning tree, cut-vertices and separability, shortest path algorithms; depth-first and breadth first search on a graph; planarity testing; isomorphism.	9
3.	**Graphs in Switching and Coding Theory:** Analysis and synthesis of connected networks, sequential switching networks, unit cube and its graph, graphs in coding theory.	7
4.	**Graph Theory in Operations Research:** Transport network, flows.	4
5.	**Enumeration of Graphs:** Types of enumeration; counting labeled and unlabeled trees; Polya's counting theorem.	5
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Deo N., “Graph Theory with Applications to Engineering and computer Science”, Prentice Hall of India..	**1992**
2.	Bela B., “Modern Graph Theory”, Springer.	**2005**
3.	Harrary F., “Graph Theory”, Addison Wesley.	**1969**
4.	Cormen T.H., Leiserson C.E.and Rivest R.L., “Algorithms”, Prentice Hall of India.	**2000**
5.	Agnarsson G., Greenlaw R., “Graph Theory : Modeling, Applications, and Algorithms”, Pearson Education.	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-533** Course Title: **Software Engineering**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Basic knowledge of software related concepts.**

9. Objective: To introduce the fundamentals of software development, design and its implementation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Software engineering approach to solve problems of software industry.	2
2.	**Software Processes**: Software development process, project management process.	4
3.	**Software Requirement Analysis and Specification:** Software requirements, problem analysis, requirement specification and validation.	4
4.	**Software Planning:** Cost estimation, COCOMO model, staffing and personnel planning, software configuration and management plan, quality assurance plan, monitoring plans.	6
5.	**Software Design:** Design concepts, abstraction, modularity, structure, concurrency, information hiding, coupling and cohesion, detailed design considerations, verification, complexity, metrics.	5
6.	**Implementation Issues:** standards and guidelines, verification and validation techniques, quality assurance, static analysis, symbolic execution, unit testing, metrics.	4
7.	**Testing Fundamentals**: Functional testing, testing process, software reliability.	3
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Fairley R., “Software Engineering Concepts”, Tata McGraw-Hill.	**1997**
2.	Pressman R.S., “Software Engineering: A Practitioner’s Approach”, McGraw-Hill, Inc.	**1992**
3.	Sommerville I.., “Software Engineering”, Pearson Education Pvt. Ltd.	**2006**
4.	Jalote P., “An Integrated Approach to Software Engineering”, Narosa Publishing House.	**2004**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-621** Course Title: **Approximation Theory**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-510.**

9. Objective: To provide the concepts of best approximation and various tools of approximation theory.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Concept of best approximation in a normed linear space, existence of a best approximation, uniqueness problem, convexity-uniform, strict and their relations, continuity of best approximation operator.	**6**
2.	The Weierstrass theorem, Bernstein and modified Bernstein polynomials, monotone operators, Korovkin's theorems, Lipschitz class, modulus of continuity and integral modulus of continuity, their properties.	**8**
3.	Bernstein's inequality, Jackson's theorem and its converse, saturation theorems.	**8**
4.	Linear and iterative combination of positive linear operators, simultaneous approximation, L^P –approximation.	**6**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Cheney E.W., “Introduction to Approximation Theory”, Chelsea.	**1982**
2.	Mhaskar H.N., Pai D.V., “Fundamentals of Approximation Theory”, Narosa Publishing House.	**2000**
3.	Lorentz G.G., “Bernstein Polynomials”, University of Toronto Press.	**1986**
4.	Timan A.F., “Theory of Approximation of Functions of a Real Variable”, Hindustan Publishing Corporation.	**1994**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-622** Course Title: **Wavelet Theory**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide the basic knowledge of Fourier analysis, time frequency analysis and wavelets transforms .

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Review of Trigonometric Fourier Series**	**2**
2	**Advanced Fourier Analysis:** Gibbs phenomenon, modulus of continuity, integral modulus of continuity, summability of Fourier series, Bessel's inequality, Parseval's relations in L_1 and L_2 spaces, evaluation of improper integrals using Parseval's relations, Poisson's summation formula.	**5**
3.	**Time Frequency Analysis:** The Gabor transform, short time Fourier transform, common window functions, windowed functions, the uncertainty principles, B-splines, classical Shannon sampling theorem, frames and tight frames.	**10**
4.	**Wavelet Transforms:** Wavelet transform, wavelet series, integral wavelet transform, basic wavelet, orthogonal wavelets and compactly supported wavelets, wavelet decomposition, reconstruction of wavelets and applications.	**8**
5.	**Applications of Wavelets**	**3**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Chui C.K., "An Introduction to Wavelets", Academic Press.	**1992**
2.	Bachman G., Narici L. and Beckenstein E., "Fourier and Wavelet Analysis", Springer University Text.	**2005**
3.	Pinsky M. A., "Introduction to Fourier Analysis and Wavelets", Thomson Brooks/Cole.	**2002**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-623** Course Title: **Dynamical Systems**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-501.**

9. Objective: To provide knowledge about the linear, nonlinear and discrete dynamical systems, bifurcation , chaos, and spatio temporal patterns.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Linear Dynamical Continuous Systems:** Introduction, equilibrium points, phase space, trajectories, classification.	4
2.	**Nonlinear Autonomous Systems:** Local and global stability, limit cycles, Poincare Bendixon theorem, more complicated attractors, dissipative and conservative systems.	6
3.	**Discrete Systems:** Logistic maps, equilibrium points and their stability, cycles, period doubling, chaos , tent map, horse shoe map.	4
4.	**Local Bifurcation:** Fixed points, saddle node, pitchfork bifurcation, transcritical bifurcation, Hopf bifurcation.	5
5.	**Deterministic Chaos:** Duffing oscillator, Lorenz system, Liapunov exponents, Routes to chaos , necessary conditions for chaos.	5
6.	**Spatio Temporal Patterns in Reaction Diffusion Equations**: Homogeneous pattern, traveling waves, Turing instability and pattern ,Introduction to non-linear partial differential equations and pattern formation.	4
	Total	28

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Laxmanan M, Rajshekharan S., "Nonlinear Dynamics: Integrability, Chaos and Patterns", Springer.	**2003**
2.	Nogoshima H., "Introduction to Chaos", Institute of Physics	**1999**
3.	Wiggins S., "Introduction to Applied Nonlinear Dynamical System and Chaos", Springer.	**2003**
4.	Hubbard, J.H., West B.H., "Differential Equation: A Dynamical Systems Approach", Springer Verlag.	**1990**
5.	Adison P.S. ," Fractal and Chaos : An illustration Course", Overseas Press India.	**2005**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-625** Course Title: **Finite Element Methods**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Both** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-202M.**

9. Objective: To impart knowledge of finite element methods for solving ordinary differential equations and partial differential equations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to finite element methods, comparison with finite difference methods.	**2**
2.	Methods of weighted residuals, collocations, least squares and Galerkin's method.	**4**
3.	Variational formulation of boundary value problems equivalence of Galerkin and Ritz methods.	**4**
4.	Applications to solving simple problems of ordinary differential equations.	**3**
5.	Linear, quadratic and higher order elements in one dimensional and assembly, solution of balanced system.	**5**
6.	Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements, curved boundaries and isoperimetric elements and their assembly.	**6**
7.	Applications for solving partial differential equations.	**4**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Reddy J.N., “Introduction to the Finite Element Methods”, Tata McGraw-Hill.	**2003**
2.	Bathe K.J., “Finite Element Procedures”, Prentice-Hall.	**2001**
3.	Cook R. D., Malkus D.S. and Plesha M. E, “Concepts and Applications of Finite Element Analysis”, John Wiley.	**1989**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-626** Course Title: **Advanced Functional Analysis**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-510.**

9. Objective: To give deep in depth knowledge of advanced topics of functional analysis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of Banach spaces, Hilbert spaces, continuous linear transformations, dual spaces.	**4**
2.	Weak and strong convergence, reflexive Banach spaces, adjoint operators on Banach spaces.	**5**
3.	Compact operators, Riesz-lemma, Arzela-Ascolli theorem.	**5**
4.	Orthogonal projections on Hilbert spaces and Banach spaces, spectrum of linear operators on finite and infinite dimensional spaces.	**6**
5.	Nonlinear operators, contraction mappings, fixed point theorems and its applications to differential equations and integral equations.	**4**
6.	The Gateaux and Frechet derivatives, their uniqueness and their relations, Sobolev spaces..	**4**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Yoshida K., "Functional Analysis", Academic Press.	**1998**
2.	Pazy A., "Semigroup of Linear Operators and Applications to Partial Differential Equations", Springer Verlag.	**1983**
3.	Maddox I.F., "Elements of Functional Analysis", 2nd Ed; Cambridge Univ. Press.	**1999**
4.	Rudin W., "Functional Analysis", 2nd Ed., McGraw Hill.	**1991**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-627** Course Title: **Theory of Vibrations**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-504**

9. Objective: To acquaint the students with linear and nonlinear theory of vibrations.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Linear Vibrations:** Vibrations of systems with one degree of freedom, natural, damped and forced vibrations, energy in vibrating systems.	6
	Systems with two or more degrees of freedom, applications of Lagrange's equations, normal modes,	8
	Vibration of continuous systems, vibrations of rods, beams.	6
2.	**Nonlinear Vibrations:** Vibrations of systems with nonlinear restoring systems and nonlinear damping.	2
	Duffing's and Vander Pol's equations and their solutions by direct iteration and perturbation methods.	6
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Maclachlan N.W., “Theory of Vibrations”, Dover Publications.	**1985**
2.	Bickley W.G.and Talbot A., “Theory of Vibrating Systems”, Oxford University Press.	**1970**
3.	Hayashi C., “Non-linear Oscillations in Physical System”, Tata McGraw-Hill.	**1964**
4.	Thomson W.T.and Dahleh M.D., “Theory of Vibrations with Applications”, Pearson Education.	**2005**
5.	Rao S.S., “Mechanical Vibrations”, Pearson Education.	**2006**
6.	Nayfeh A. H. and Mook D. T., " Non-linear Oscillations" Wiley - IEEE	**1979**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-628** Course Title: **Computational Fluid Dynamics**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: SPRING** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Basic concepts of fluid dynamics and numerical analysis.**

9. Objective: To introduce finite difference methods used in computational fluid dynamics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	General Navier-Stokes (N-S) equations, various forms of N-S equations, dimensionless form, N-S equation.	**3**
2.	Discrete approximations, upwind corrected scheme, higher order methods, Hermitian method and Mehrstellen methods, multidimensional equation, explicit schemes for the advection-diffusion equations, ADI method, explicit schemes for a nonlinear equation in conservative form, generalized ADI methods.	**7**
3.	Incompressible viscous flow via FDM**,** artificial compressibility method, pressure correction methods, SIMPLE, pressure implicit with splitting of operators, Marker and Cell method (MAC).	**8**
4.	Finite volume methods via FDM,2-D problem, node centered control volume, cell centered control volume, cell centered average scheme, three dimensional problems, 3-D geometry structure, 3-D FVM equations; Illustrative problems.	**10**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Anderson J.D., “Computational Fluid Dynamics”, McGraw Hill.	**1995**
2.	Patankar S. V., “Numerical Heat Transfer and Fluid Flow”, Taylor and Francis	**2004**
3.	Roger P. , Thomas D. Taylor, “Computational Methods for Fluid Flow”, Springer Verlag.	**1983**
4.	Chung T.J., “Computational Fluid Dynamics”, University Press	**2003**
5.	Murlidhar K. ,Sundararajan T., “Computational Fluid Flow and Heat Transfer”, Narosa .	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-629** Course Title: **Hydrodynamic Stability**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-501, MA-506 and MA-603.**

9. Objective: To introduce the concepts of linear and weakly nonlinear hydrodynamic stability.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction, mechanism of instability, fundamental concept of hydrodynamic stability, thermal instability, Rayleigh Taylor instability, Kelvin's instability, centrifugal instability.	**9**
2.	Stability of non-linear systems.	**3**
3.	The linearized equations, boundary conditions, normal mode-analysis, exchange of stabilities.	**5**
4.	The governing equations, general criteria for instability for invicid fluid, the eigen value spectrum for small Reynold's numbers, sufficient conditions for stability using energy analysis.	**6**
5.	Finite amplitude analysis, Echans method, power series method, plane Poiseuille flow.	**5**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Drazin P.G. , Reid W.H., “Hydrodynamic Stability”, Cambridge Univ. Press.	**1981**
2.	Chandrasekhar S., “Hydrodynamic and Hydromagnetic Stability”, Dover Publications.	**1961**
3.	Denn M. M., “Stability of Reaction and Transport Process”, Prentice Hall of India.	**1973**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-630** Course Title: **Introduction to Fracture Mechanics**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-504**

9. Objective: To provide knowledge of linear elastic, elastic-plastic and non-metals fracture mechanics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** fracture mechanics approach to design, effect of material properties on fracture.	3
2.	**Linear Elastic Fracture Mechanics (LEFM):** An atomic view of fracture stress concentration views of flaws, Griffith energy balance, energy release rate.	3
3.	**Mathematical Foundation and Solution of LEFM Problems:** Stress analysis of cracks, relationship between K and G, crack tip plasticity, K- controlled fracture, plane stress fracture, mixed mode fracture, plane elasticity, crack growth instability, crack tip analysis	6
4.	**Elastic-Plastic Fracture Mechanics (EPFM):** Crack tip opening displacement, relation between J and CTOD, crack growth resistance curve, crack-tip constraint under large-scale yielding.	3
5.	**Mathematical Foundation and solution of EPFM Problems:** Determining CTOD from the strip yield model, analysis of stable crack growth rate in small scale yielding, J contour integral, J as non linear energy release rate.	6
6.	**Fracture Mechanics of Non-Metals, Simple Applications:** Structure and properties of polymers, yielding and fracture of polymers, ceramics and ceramic composites.	7

	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Anderson T.L., “Fracture Mechanics”, CRC Press	**2002**
2.	Lunger D.J., “Analytic Fracture Mechanics”, Dover Publication.	**1995**
3.	Gdoulsas E.E., “Fracture Mechanics: An Introduction to Solid Mechanics and its Applications”.	**2006**
4.	Nestor P., “Fracture Mechanics (Mathematics and its Applications)”, Mc-Graw Hill.	**2006**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-631** Course Title: **Advanced Fluid Dynamics**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-603.**

9. Objective: To introduce some advanced topics in fluid dynamics and the mathematical formulation of stability problems in fluid flow and classification of fluids with their constitutive equations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Dimensional analysis, large Reynold's numbers; Laminar boundary layer equations, similar solutions; Flow past a flat plate, momentum integral equations, solution by Karman-Pohlhausen method, impulsive flow, Reyleigh problem, thermal boundary layer equation for incompressible flow; Temperature distribution in Coutte flow and in flow past a flat plate, Compressible boundary layer when Prandtl number is unity.	**10**
2.	Mathematical formulation of the stability problem of an incompressible flow and stability of flows between two infinite parallel plates, Reynold's theory of turbulence, Prandtl's momentum transfers theory, turbulent flow through a smooth tube.	**12**
3.	Fluids and their classification and constitutive equations, power law; Flow past a flat plate and flow through tubes and channels.	**6**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Rosenhead, “Laminar Boundary Layers”, Dover	**1963**
2.	Schliting H , Gersten K., “Boundary Layer Theory”, Springer	**2004**
3.	Wilkinson W.L., “Non-Newtonian Fluids”, Pergamon Press	**1960**
4.	Drazin P.G. , Reid W.H., “Hydrodynamice Stability”, Cambridge	**2004**
5.	Chandrasekhar S., “Hydrodynamic and Hydromagnetic Stability”, Dover.	**1981**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-632** Course Title: **Advanced Mathematical Modeling**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-501 and MA-506.**

9. Objective: To impart knowledge of mathematical modeling of real life problems such as flow in bio-system, air-pollution, traffic flow and management of renewal resources.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Simple pendulum, motion of satellites, curve of pursuit.	**3**
2.	**Flow in bio-systems:** Constitutive equations, Special characteristics of blood flow, models in cardiovascular system, pulsatile and peristaltic flow, stenosis (arthrosclerosis)	**9**
3.	**Diffusion models in air pollution:** Eddy diffusivity, distribution of gaseous pollutants, deposition of air borne material	**6**
4.	**Traffic flow:** Fundamentals of traffic flow, parameters and their relation, wave phenomenon, shock waves, traffic jams and traffic lights	**6**
5.	**Optimal management of renewable resources**: Population growth models with harvesting, Models in fisheries and forestry	**4**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Jones D. S., Sleeman B. D., "Differential Equations and Mathematical Biology", Chapman & Hall.	**2003**
2.	Lightfoot E. N., "Transport Phenomena and Living Systems", Wiley Interscience.	**1974**
3.	Clark C. W., "The Optimal Management of Renewable Resources", Wiley Interscience.	**1990**
4.	Kapur J. N., "Mathematical models in Biology and Medicine Applied", Eastern Press.	**1985**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MA-633** Course Title: **Lebesgue Measure & Integration**

2. Contact Hours: **L: 2** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 3 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **MA-503**

9. Objective: To provide concepts about the theory of measure and integration on real line.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of Lebesgue measure properties, measurable functions, approximation of measurable functions, Egorof's theorem, simple functions, Littlewood's three principles, convergence in measure.	**08**
2.	Lebesgue integral of simple functions, integration of bounded & measurable functions and of non-negative functions, monotone convergence theorem, Fatou's lemma, general Lebesgue integral, dominated convergence theorem, comparison of Lebesgue and Riemann integrals.	**08**
3.	Differentiation of monotone functions, Dini's derivatives, functions of bounded variation, absolute continuity, differential of an integral.	**06**
4.	L^p –Spaces, Holder's and Minkowski's inequalities, completeness of L^p –spaces, convergence in mean, bounded linear functions on L^p –spaces, Riesz representation theorem.	**06**
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Halmos P.R., “Measure Theory”, Springer.	**1978**
2.	Royden H.L., “Real Analysis”, 3rd Ed, Collier McMillan.	**1988**
3.	Rudin W., “Real and Complex Analysis”, McGraw Hill.	**1987**