INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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**: PCC**

8. Pre-requisite**:** Nil

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

10. Details of Course

S. No.	Contents	Contact Hours
1.	**Riemann Integrals:** Existence and properties of the integrals, Fundamental theorem of calculus, first and second mean value theorems.	**10**
2.	**Metric Spaces:** Review of complete metric spaces, compact metric spaces, compactness and uniform continuity and connected metric spaces.	**12**
3.	**Measures:** Introduction to the properties of general measure and measurable spaces, Borel Algebras, complete measure.	**5**
4.	**Lebesgue Measures:** Measurable sets and their properties, translation invariance and completeness of Lebesgue measure Lebesgue integral of a simple function, comparison of Lebesgue and Riemann integrals.	**15**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Aliprantis, C.D. and Burkinshaw, W., Principles of Real Analysis, Elsevier	2011
2.	Apostol, T. M., Mathematical Analysis, Narosa Publishing House.	2002
3.	Barra, G. D., Measure theory and Integration, Woodhead Publishing.	2003
4.	Royden, H.L., Real Analysis, The Mcmillion company	2010
5.	Rana, I. K. , An Introduction to Measure and Integration, Narosa Publishing House.	2007
6.	Rudin, W., Principles of Mathematical Analysis, McGraw-Hill Book Company.	1976

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-507** 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**: PCC**

8. Pre-requisite**: Nil**

9. Objective: To give an introduction to the basic concepts of Abstract Algebra.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Groups:** Groups and their homomorphisms, Normal Subgroups, Quotient Groups, Isomorphism Theorems. Group actions, Cayley's Theorem, Class Equation of a group, Cauchy's Theorem, p-groups, Sylow's Theorems and their applications.	**15**
2.	**Rings:** Rings, Ideals and Homomorphisms, Quotient rings, Isomorphism theorems, Prime and Maximal ideals, Rings of fractions, Integral domain, Euclidean Domains, Principal Ideal Domains and Unique Factorization Domains. Polynomial rings over UFD's, Criteria for irreducibility of polynomials over UFD's.	**12**
3.	**Modules:** Basic definitions and examples, Submodules and Direct sums, Quotient modules, Homomorphism and Isomorphism theorems, Cyclic modules, Free modules.	**5**
4.	**Fields:** Fields and their extensions, Algebraic and finitely generated field extensions, Splitting fields and normal extensions, Algebraic closures, Finite fields, Separable and inseparable extensions. Galois groups, Fundamental Theorem of Galois Theory.	**10**
	TOTAL	**42**

11. Suggested Books:

S. No.	Title/Authors/Publishers	Year of Publication
1.	Dummit D. S. and Foote R. M., "Abstract Algebra", John Wiley & Sons (3rd Edition)	2003
2.	Bhattacharya P. B., Jain S. K. and Nagpaul S. R., "Basic Abstract Algebra", Cambridge University Press (2nd Edition)	1995
3.	Herstein I. N., "Topics in Algebra", John Wiley & Sons (2nd Edition)	1999
4.	Hungerford T. W., "Algebra", Springer	1980
5.	Lang S., "Algebra", Springer (3rd Edition)	2005
6.	Jacobson N., "Basic Algebra Vol. 1" Dover Publications (2nd Edition)	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-509** Course Title: **Computer Programming**

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

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

4. Relative Weightage**: CWS 15 PRS 25 MTE 20 ETE 40 PRE 0**

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

8. Pre-requisite**:** Nil

9. Objective: To provide the basic knowledge of C++ programming.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basic Computer Fundamentals:** Introduction to computer systems; number system, integer, signed integer, fixed and floating point representations; IEEE standards, integer and floating point arithmetic; CPU organization, ALU, registers, memory, the idea of program execution at micro level.	**07**
2.	**Basic Programming in C++:** Input/output; Constants, variables, expressions and operators; Naming conventions and styles; Conditions and selection statements; Looping and control structures (while, for, do-while, break and continue); Arrays; File I/O, header files, string processing; Pre-processor directives such as #include, #define, #ifdef, #ifndef; Compiling and linking.	**10**
3.	**Programming through functional decomposition:** Design of functions, void and value returning functions, parameters, scope and lifetime of variables, passing by value, passing by reference, passing arguments by constant reference, recursive functions; Function overloading and default arguments; Library functions.	**08**
4.	**Pointers:** Pointers; Dynamic data and pointers, dynamic arrays, use of pointers in linked structures.	**05**
5.	**Object Oriented Programming Concepts:** Data hiding, abstract data types, classes, access control; Class implementation, constructors, destructor	**12**
	operator overloading, friend functions; Object oriented design (an alternative to functional decomposition) inheritance and composition; Dynamic binding and virtual functions; Polymorphism; Dynamic data in classes.	
	Total	**42**

11. Suggested Books:

S. No.	Name of the Authors / Books / Publisher	Year of Publication/ Reprints
1.	Deitel, H. M. and Deitel, P. J., C++ How to Program. Prentice Hall, 8th Ed.	2011
2.	Eckel, B., Thinking in C++ Volume 1 & 2. Prentice Hall, 2nd Ed.	2003
3.	Schildt, H., C++: The Complete Reference, McGraw-Hill, 4th Ed.	2002
4.	Lafore, R., Object-Oriented Programming in C++. Sams Publishing, 4th Ed.	2001
5.	Lippman, S. B. and Lajoie, J. and Moo, B.E., The C++ Primer. Addison-Wesley Professional, 5th Ed.	2012
6.	Stallings, W., Computer Organization and Architecture: Designing for Performance. Prentice-Hall, 7th Ed.	2005
7.	Stroustrup, B., The C++ Programming Language. Addison-Wesley, 3rd Ed.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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**: 04** 6. Semester**: Spring** 7. Subject Area**: PCC**

8. Pre-requisite**:** Basic course in Numerical methods

9. Objective: To impart knowledge of numerical analysis in solving differential equations.

10. Details of Course:

S.No.	Contetns	Contact Hours
1.	**Computations of Eigen Values of a Matrix:** Power method for dominant, sub-dominant and smallest eigen-values, Method of inflation, Jacobi, Givens and Householder methods for symmetric matrices, LR and QR methods.	**10**
2.	**Solution of ODE** : Multistep methods; Predictor-corrector Adam-Bashforth Milne's method , their error analysis and stability analysis	**6**
3.	**Finite Difference**: Review of finite difference operators, finite difference methods, Inverse interpolation, their developments and applications	**6**
4.	**Elliptic PDE**: Five point formulae for Laplacian, replacement for Dirichlet and Neumann's boundary conditions, curved boundaries, solution on a rectangular domain, block tri-diagonal form and its solution using method of Hockney, condition of convergence	**5**
5.	**Parabolic PDE**: Concept of compatibility, convergence and stability, Explicit, full implicit, Crank-Nicholson, du-Fort and Frankel scheme, ADI methods to solve two-dimensional equations with error analysis.	**5**
7.	**Hyperbolic PDE**: Solution of hyperbolic equations using FD, and Method of characteristics ,Limitations and Error analysis	**5**
8.	**Weighted residual methods**: Collocation, least squares, Galerkins, Rayleigh-Ritz methods and their compatibility	**5**
	TOTAL	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Gerald, C. F. and Wheatly P. O., "Applied Numerical Analysis", 6th Ed., 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
4.	Fausett, L. V., "Applied Numerical Analysis", Prentice Hall, 2nd Ed.	2007
5.	Froberg, C. E., "Introduction to Numerical Analysis", 2nd Ed., Addison Wesley.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-504** Course Title: **Linear Algebra**

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

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

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

5. Credits: **04** 6. Semester: **Spring** 7.Pre-Requisite: Nil

8.Subject Area: PCC

9. Objective of the Course: To introduce some advanced topics of linear algebra

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Vector Spaces &Linear Transformations:** Review of vector spaces, basis and dimension, examples of infinite dimensional spaces, ordered bases and coordinates, linear transformations, algebra of linear transformations, rank-nullity theorem, matrix representation of a linear transformation, change of basis, linear functional, dual spaces, reflexivity.	8
2	**Modules** Review of basic properties of modules, rank of a free module and epimorphisms, Noetherian module, Hilbert basis theorem, free module over a principal ideal domain, torsion free and free modules, primary decomposition, cyclic decomposition of a primary module, the invariant factor decomposition.	8
3	**Linear Operators : B**rief review, the module associated with a linear operator, orders and the minimal polynomial, cyclic modules and cyclic sub spaces, the decomposition of vector space V, the rational canonical form, characteristic polynomial of an operator, eigenvalues and eigenvectors of linear operators, eigen-space, minimal polynomial,Jordan canonical form, triangularizability and Schur'slemma, diagonalizable operators, projections, algebra of projections, resolution of the identity, spectral resolution, exponential of a square matrix	12
4	**Inner Product Space:** Inner product between two vectors, orthogonal and orthonormal vectors, normed space, isometries, projection theorems and best approximations, orthogonal direct-sum,Riesz representation theorems, adjoint of a linear operator, unitary diagonalizability, normal operators, special types of normal operators ,self-adjoint operators ,unitary operators and isometries, structure of normal operators, orthogonal projection, orthogonal resolution of identity, spectral theorem, positive operators. Gram-Schmidt process for orthogonalisation, projection operator, quadratic forms, positive definite forms.	14
	TOTAL	**42**

11. Suggested Books :

S. No.	Name of Books/Authors/Publishers	Year of publications
1	Roman,S., ”Advanced Linear Algebra”Springer	2005
2.	Hoffman, K. and Kunze, R., "Linear Algebra", 2nd edition, Pearson Education (Asia) Pvt. Ltd/ Prentice Hall of India	2004
3.	Leon, S.J., "Linear Algebra with Applications", 8th Edition, Pearson	2009
4.	Peter, J. Olever and Shakiban, C., "Applied Linear Algebra", 1st Edition , Prentice Hall	2005
5.	Strang, G., "Linear Algebra and its Applications", 3rd edition, Thomson Learning Asia Pvt Ltd	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1.Subject Code: **MAN-506** Course Title : **Probability & Statistics**

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

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

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

5. Credits: **04** 6. Semester: **Spring** 7.Pre-Requisite: Nil
8.Subject Area: **PCC**

9. Objective of the Course: To impart knowledge of Probability and Statistics.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Random variable:** Distribution functions, probability mass function and probability density function, moments and moment generating functions. Chebyshev's inequality, law of large numbers, central limit theorem	07
2	**Special distributions:** Binomial, Poisson, Negative binomial, Geometric, Hypergeometric. Uniform, Exponential, Gamma, Beta, Weibull, Normal, Lognormal, Pearsons.	06
3	**Bivariate random variables:** Statistical independence, joint, marginal, conditional distribution, Product moment, correlation, regression, function of random variables and their probability distribution.	07
4	**Sampling:** Random sampling with replacement and without replacement, Sampling distribution on samples from normal population: normal, t, χ^2, F distribution.	04
5	**Theory of estimation:** Basic concepts of estimation, point estimation, methods of estimation, method of moments, method of maximum likelihood, unbiasedness, minimum variance estimation, interval estimation.	09
6.	**Testing of hypothesis:** Null and alternative hypothesis, type I and II errors power function, method of finding tests, likelihood ratio test, Neyman Pearson lemma, uniformly most powerful tests, some results based on normal population.	09
	TOTAL	42

11. Suggested Books :

S.No.	Author/Books/Publishers	Year of Publications
1.	Miller, I. and Miller, M: John E. Freund's Mathematical Statistics with Appliation, (Prentice Hall)(7^{th} edition)	2006
2.	Hogg, R. V., McKean, J. and Craig, A. : Introduction to Mathematical Statistics, (Pearson Education) (7^{th} Ed.)	2006
3.	Rohatgi, V.K and Md. Ehsanes Saleh, A.K. : An Introduction to Probability and Statistics,(John Wiley and Sons),(2^{nd} edition)	2000
4.	Casella, G., Berger, R..: Statistical Inference. 2nd edition, Duxbury Press	2002
5.	Rao, C.R. : Linear statistical Inference and its application (Wiley Eastern Ltd) (2^{nd} Ed.)	2002
6.	Lehmann, E.L. and Joseph P. Romano : Testing Statistical Hypothesis (Springer) (3^{rd} Ed.)	2005
7.	Lehmann, E.L. and Casella George : Theory of Point Estimation (Springer) (2^{nd} Ed.)	1998
8.	Papoulis, A. and Pillai, S.U. Probability, Random Variables and Stochastic Processes(Tata McGraw-Hill) (fourth edition)	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-510** Course Title: **Complex Analysis**

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**

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

8. Pre requisite**:** A first course on Complex Analysis

9. Objective: To provide advance topics in functions of one complex variable.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Complex Integration:** Revisit to Cauchy Integral formula, Winding Numbers , Morera's theorem, Maximum modulus principle, Schwarz Lemma, Meromorphic function, the Argument Principle , Rouche's theorem, improper integrals, evaluation of a real integral, improper integrals involving sines and cosines, integration through branch cut.	14
2.	**Conformal Mapping:** Definition, Bilinear transformation, Cross ratio, the mappings from disc to disc, disc to half plane and half plane to half plane. mapping of elementary transformations, Schwarz, Christoffel transformation and their applications.	10
3.	**Applications:** Applications of conformal mapping to steady temperature, electrostatic potential, two dimensional fluid flow, stream function, Poisson integral formula, Dirichlet problem in the unit disc, Dirichlet problem in the half plane, Neumann problem for the disc and the half plane.	12
4.	**Analytic Continuation**: Definition and uniqueness of analytic continuation, standard method of analytic continuation using power series, the principle of reflection.	6
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Ahlfors, L.V., Complex Analysis, McGraw Hill	1988
2.	Conway, J.B., Functions of one complex Variables I, Narosa Publishing House.	2000
3.	Gamelin, T.W., Complex Analysis, Springer,Verlag	2001
4.	Greene, R. and Krantz, S.G., Function Theory of One Complex Variable, 3rd Edition, GSM, Vol. 40, American Mathematical Society.	2006
5.	Lang, S., Complex Analysis, Springer , Verlag.	2003
6.	Mathews, J.H. and Howell, R.W., Complex Analysis for Mathematics and Engineering, Narosa	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-607** Course Title: **Operations Research**

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

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

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

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

8. Pre-requisite: Nil

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

10. Details of the course:

S. No.	Contents	Contact Hours
1	**Basics of LPP:** Different Types of OR Models, Convex Sets, Graphical Method, Simplex Method, Big –M Method, Two Phase Method, Revised Simplex Method.	11
2	**Duality Theory**: Dual Simplex Method, Sensitivity Analysis, Parametric Linear Programming .	9
3	**Integer Program:** Cutting Plane and Branch and Bound Techniques for all Integer and Mixed Integer Programming Problems .	5
4	**Transportation Problems**: Transportation Problems and Assignment Problems .	5
5	**Game Theory:** Graphical Method and Linear Programming Method for Rectangular Games, Saddle point, notion of dominance .	5
6	**Queuing Theory:** Steady -state solutions of Markovian Queuing Models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited space, M/G/1, Inventory Models.	7
	TOTAL	42

11. Suggested Books:

S. No.	Name of Books/ Authors/ Publishers	Year of Publication
1	Mohan, C. and Deep,K.: “Optimization Techniques”, New Age India Pvt. Ltd, New Delhi.	2009
2	Mittal, K.V. and Mohan, C.: “Optimization Methods in System Analysis and Operations Research”, New Age India Pvt. Ltd, New Delhi.	1996
3	Taha, H.A. : “Operations Research: An Introduction”, MacMillan Pub Co., NY, Ninth Edition (Reprint).	2013
4	Ravindran, A., Phillips, D.T. and Solberg, J.J.: “Operations Research: Principles and Practice”, John Wiley and Sons, NY, Second Edition (Reprint).	2012
5	Pant, J.C.: “Introduction to Optimization/ Operations Research”, Jain Brothers, New Delhi, Second Edition.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-520** Course Title: **Graph Theory**

2. Contact Hours: **L: 3** **T: 0** **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: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Prerequisite: Nil

9. Objective: To introduce the basic concepts of graph theory and its applications

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction to Graphs:** Definition of a graph, finite and infinite graphs, incidence of vertices and edges, types of graphs, subgraphs, walks, trails, paths, cycles, connectivity, components of a graph, Eulerian and Hamiltonian graphs, travelling salesman problem, vertex and edge connectivity, matrix representation of graphs, incidence and adjacency matrices of graphs	10
2.	**Trees and Fundamental Circuits:** Definition and properties of trees, rooted and binary trees, counting trees, spanning trees, weighted graphs, minimum spanning tree, fundamental circuit, cut set, separability, network flows	6
3.	**Vector Spaces associated with Graphs:** Galois fields, Vector spaces associated with graphs, orthogonal vectors and spaces	4
4.	**Planar graphs and graph coloring:** Planar graphs, Kuratowski's graphs, detection of planarity, Euler's formula for planar graphs, geometric and combinatorial duals of a planar graphs, coloring of graphs, chromatic numbers, chromatic polynomial, chromatic partitioning, Four color theorem.	6
5.	**Directed Graphs:** Types of digraphs, digraphs and binary relations, directed paths and connectedness, Euler digraphs, de Brujin sequences, tournaments	6
6.	**Ramsey Theory:** Introduction to Ramsey theory, Ramsey numbers, Ramsey theorem	4
7.	**Enumerations:** Types of enumerations, Polya theory of enumeration and its applications.	6
	Total	42

11. Suggested Books:

S. No.	Title/Authors/Publishers	Year of Publication
1.	Deo, N., “Graph Theory with Applications to Engineering and Computer Science”, Prentice Hall India	2004
2.	West, D. B., "Introduction to Graph Theory ", Prentice Hall India (2nd Edition)	2009
3.	Clark, J. and Holton, J. A.,"A First Look at Graph Theory", World Scientific	1991
4.	Aldous, J. M., Wilson, R. J. and Best S., “Graphs and Applications: An Introductory Approach”, Springer	2003
5.	Deistel, R., “Graph Theory”, Springer (4th Edition)	2010
6.	Chartrand, G. and Zhang, P., "Introduction to Graph Theory", Tata McGraw Hill	2007
7.	Bondy, J. A. and Murty, U. S. R., “Graph Theory”, Springer	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1.Subject Code : **MAN-524** Course Title: **Mechanics**

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

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

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

5. Credits: **03** 6. Semester: **Spring**

7.Pre-Requisite: Nil 8.Subject Area: **PEC**

9. Objective of the Course: To introduce basic concepts of mechanics.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Equilibrium of forces in 3D:** Condition of equilibrium for a system of forces in 3D, finite and infinitesimal displacements of a rigid body, work, potential energy virtual work, D'Alembert's principle.	6
2	**Motion of rigid body:** General motion of a rigid body, momental ellipsoid and principal axes, kinetic energy, and angular momentum of a rigid body, principles of energy and momentum, moving frames of reference, Coriolis force.	12
3	**Lagrange's and Hamilton theory:** Generalized forces, Lagrange's equation of motion, Lagrangian function, generalized momentum, deduction of principle of energy from Lagrange's equations(conservative field), Lagrange's equations with impulsive forces, Hamilton formulation, Hamilton to Lagrangian, Ignoration of coordinate and Routh's product procedure,Hamilton principle,Lagrange's eqution by varaitional methods, derivative of Lagrange's equation from Hamilton principle.	12
4	**Small oscillations:** The general theory of small oscillation, stable equilibrium and small oscilllation, the approximate forms of T and V, normal modes, orthogonality of normal modes.	12
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of publications
1	Synge, J.L. and Griffith, B.A., "Principles of Mechanics", McGraw-Hill	1970
2.	Gregory, R.D., "Classical Mechanics", First South Asian Edition, Cambridge Univ. Press	2008
3.	Goldstein, H., "Classical Mechanics", Addison-Wesley Publishing Company	1970
4.	Rana, N.C and Joag, P.S,"Classical Mechanics", Tata McGraw-Hill.	1991
5.	Louis, N. Hand and Janet, D. Finch, Analytical Mechanics, Cambridge University Press.	1998
6.	Ramsey, A.S., "Dynamics Part II", Cambridge Univ. Press	1961

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-619** Course Title: **Measure Theory**
2. Contact Hours: **L: 3** **T: 0** **P: 0**
3. Examination Duration (Hrs.): **Theory 3** **Practical 0**
4. Relative Weightage: **CWS 25** **MTE 25** **ETE 50** **PRS 0**
5. Credits: **3** 6. Semester: **Autumn/Spring**
7. Subject Area: **PEC**
8. Pre-requisite: A first course on Real Analysis
9. Objective: To provide the knowledge of Lebesgue Measure and L^p spaces.
10. Details of Course

S. No.	Contents	Contact Hours
1.	**Measure on the real line**: Introduction, Lebesgue outer measure, Measurable sets, Borel sets, Regular Measure, Measurable functions, Borel and Lebesgue Measurable Functions.	**5**
2.	**Integration of Functions of a real variable**: Integration of non-negative functions, Lebesgue Integral, Fatou's Lemma, Lebesgue Monotone Convergence theorem, The General Integral, Lebesgue dominated convergence theorem, Integraion of Series , Riemann and Lebesgue Integrals.	**10**
3.	**Abstract Measure spaces**: Measures and Outer Measures, Extensions of Measure , Uniqueness of the Extension, Completion of a measure , Measure spaces , Integration with respect to a measure.	**10**
4.	**Inequalities and the L^p spaces**: L^p spaces, Convex functions, Jensen's inequality, Inequalities of Holder and Minkowski, Convergence in Measure, Almost uniform Convergence.	**6**
5.	**Signed Measures and their Derivatives**: Signed Measures and the Hahn Decomposition, The Jordan decomposition, The Radon Nikodym Theorem and some applications.	**6**
6.	**Complex Measures**: Total variation, Absolute Continuity, Consequences of Radon Nikodym Theorem, Riesz Representation Theorem.	**5**
		42

11.Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	Barra, G.D., Measure theory and Integration. Woodhead Publishing.	2003
2.	Natanson, I.P., E. Hewitt, L.F. Boron, Theory of Functions of a Real Variable, Vol. I & II, Literary Licensing, LLC	2013
3.	Rana, I.K., An Introduction to Measure and Integration, Narosa Publishing House.	2007
4.	Rudin, W., Real and Complex Analysis, 3rd Ed., McGraw Hill	1987
5.	Royden, H.L., "Real Analysis", The Macmillan Company.	2010
6.	Munroe, M.E., Introduction to Measure and Integration, Addison Wesley, Mass.	1953

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-631** Course Title: **Number Theory**

2. Contact Hours: **L: 3** **T: 0** **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**: Spring** 7. Subject Area**: PEC**

8. Pre-requisite**: Nil**

9. Objective: To give an introduction of basic concepts of Number Theory.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Divisibility and prime numbers:** Divisibility, Euclidean algorithm, linear Diophantine equations, prime numbers, fundamental theorem of arithmetic, discussion on the prime number theorem.	6
2.	**Congruences:** Introduction to congruences, solutions of linear congruences, Chinese Remainder Theorem, Euler's totient function, Euler-Fermat theorem, Wilson's theorem, non-linear congruences, Hensel's lemma, primitive roots and power residues.	10
3.	**Public key cryptography:** Introduction to public key cryptography, the RSA cryptosystem.	3
4.	**Quadratic residues and quadratic reciprocity:** Quadratic residues, quadratic reciprocity, the Jacobi symbols.	6
5.	**Some functions of number theory:** The greatest integer function, arithmetic functions, Mobius function and Mobius inversion formula.	6
6.	**Continued fractions:** Finite continued fractions, infinite continued fractions, approximation to irrational numbers.	5
7.	**Algebraic numbers:** Introduction to algebraic numbers, algebraic number fields, algebraic integers, quadratic fields, units in quadratic fields, primes in quadratic fields, unique factorization, primes in quadratic fields having the unique factorization property.	6
	Total	42

11. Suggested Books:

S. No.	Title/Authors/Publishers	Year of Publication
1.	Niven I., Zuckerman H. S., and Montgomery H. L., An Introduction to the Theory of Numbers, John Wiley & Sons (5^{th} Ed.)	**1991**
2.	Hardy, G., H. and Wright, E. M, An Introduction to the Theory of Numbers, Oxford University Press (6^{th} Ed.)	**2008**
3.	Burton D., M., Elementary Number Theory, McGraw Hill (7^{th} Ed.)	**2010**
4.	Apostol T. M., Introduction to Analytic Number Theory, Springer	**1998**
5.	Baker A., A Comprehensive Course in Number Theory, Cambridge University Press	**2012**
6.	Koblitz N., A Course in Number Theory and Cryptography, Springer (2^{nd} Ed.)	**1994**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-632** Course Title: **Advanced Numerical Analysis**

2. Contact Hours: **L: 3** **T: 0** **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**: 3** 6. Semester**: Autumn/Spring** 7. Subject Area**: PEC**

8. Pre-requisite**:** Basic knowledge of numerical methods

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

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basic Concepts:** Introduction to finite elements methods, comparison with difference methods.	2
2.	**Weighted Residuals Method:** Collocations, least squares and Galerkin's method.	4
3.	**Ritz's Method:** Variational formulation of boundary value problems, equivalence of Galerkin and Ritz methods.	6
4.	**Application in ODE:** Application to solving simple problem of ordinary differential.	6
5.	**One Dimension Elements:** Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system.	6
6.	**Two Dimensional Elements:** Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly, discretization with curved boundaries	8
7.	**Interpolation and Integration:** Interpolation functions, numerical integration, and modeling considerations.	5
8.	**Application to PDE:** Solution of two dimension partial differential equations under different Geometric conditions.	5
	Total	42

11. Suggested Books

S.No.	Books/Author/Publishers	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 Plasha, M.E., "Concept and Application of Finite Element Analysis", John Wiley.	2002
4.	Thomas, J.R. Hughes, : " The Finite Element Method: Linear Static and Dynamic Finite Element Analysis" , Dover Publication.	2000
5.	George, R. Buchanan, :" Finite Element Analysis", McGraw-Hill.	1994