INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-001** Course Title: **Mathematics I**

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

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

4. Relative Weightage**:** **CWS** 25 **PRS** 00 **MTE** 25 **ETE** 50 **PRE** 0

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

8. Pre-requisite**:** **None**

9. Objective: **To provide essential knowledge of basic tools of Differential Calculus, Integral Calculus , Vector Calculus and Matrix Algebra for degree students.**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Matrix Algebra:** Elementary operations and their use in getting the Rank, Inverse of a matrix and solution of linear simultaneous equations. Orthogonal, Symmetric, Skew-symmetric, Hermitian, Skew-Hermitian, Normal & Unitary matrices and their elementary properties. Eigen-values and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix.	8
2.	**Differential Calculus:** Limit, Continuity and differentiability of functions of two variables, Euler's theorem for homogeneous equations, Tangent plane and normal. Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Error approximations. Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers	12
3.	**Integral Calculus:** Review of curve tracing and quadric surfaces, Double and Triple integrals, Change of order of integration. Change of variables. Gamma and Beta functions. Dirichlet's integral. Applications of Multiple integrals such as surface area, volumes, centre of gravity and moment of inertia..	12
4.	**Vector Calculus:** Differentiation of vectors, gradient, divergence, curl and their physical meaning. Identities involving gradient, divergence and curl. Line and surface integrals. Green's, Gauss and Stroke's theorem and their applications.	10
	Total	42

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	E. Kreyszig, Advanced Engineering Mathematics, 9th edition, John Wiley and Sons, Inc., U.K.	2011
2.	R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 2nd Edition, Narosa Publishing House.	2005
3.	M.D. Weir, J. Hass, F.R. Giordano, Thomas' Calculus, 11th Edition, Pearson Education.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-101** Course Title: **Introduction to Mathematical Sciences**

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

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

4. Relative Weightage**:** **CWS** 00 **PRS** 00 **MTE** 00 **ETE** 00 **PRE** 100

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

8. Pre-requisite**:** **None**

9. Objective: To provide introductory knowledge to the students about mathematical sciences, commonly used terminologies and History of Mathematics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction** (with simple examples) to various branches of mathematics such as: Pure mathematics, Applied mathematics, Engineering mathematics, Statistics, Operations research, Mathematical modeling.	**4**
2.	**Geometry**: Basic structures, transformations among Cartesian, polar and parametric coordinates, curves, tracing and investigation of curves..	**4**
3.	**History of Ancient mathematics**: Egypt and Mesopotamia, Number systems, Arithmetic and geometry, Hindu and Arabic, Invention of negative numbers and zero, development of algebra, roots of equations	**4**
4.	**Mathematics in Medieval period**: Distinct character of Greek Mathematics (geometry, logic, proof, axiomatic structure), Nature of problems and method of solutions, proof by contradiction, theory of incommensurables, method of exhaustion, reconsideration of infinity.	**8**
5.	**History of Modern Mathematics**: Development of calculus as the language of physics, Differential equations, Quantics, Theory of numbers, Introduction to the work of Srinivasa Ramanujan, Theory of functions, Probabilities and Least squares, Modern Geometry, Non-Euclidean geometry.	**8**
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	C.B. Boyer, History of Mathematics, Wiley International Edition, New York.	1968
2.	E. Carrucio, Mathematics and Logic in History and in Contemporary Thought, Aldine Publications company, Chicago.	1964
3.	R. Courant, H. Robbins and I. Stewart, What is Mathematics? An elementary approach to ideas and methods, Oxford University Press, Oxford.	1996
4.	Keith Devlin, Introduction to Mathematical Thinking, California.	2012
5.	Howard Eves, An introduction to History of Mathematics, Holt, Reinhart and Winston, New York.	1964
6.	G. H. Hardy and E. M. Wright, An Introduction to the Theory of Numbers, Oxford University Press.	2008
7.	V. Lakshmikantham and S. Leela, Origin and History of Mathematics, Cambridge Scientific Publishers, Cambridge	2005
8.	Sarju Tiwari, Mathematics in History, Culture, Philosophy and Science from ancient time to Modern age, Mittal Publications, New Delhi.	1992

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-103** Course Title: **Introduction to 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**: ESC**

8. Pre-requisite**:** **None**

9. Objective: To give the basic knowledge of computer 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.	**7**
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.	**9**
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.	**8**
4.	**Pointers**: Pointers; Dynamic data and pointers, dynamic arrays.	**3**
5.	**Object Oriented Programming Concepts**: Data hiding, abstract data types, classes, access control; Class implementation-default constructor, constructors, copy constructor, destructor, 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.	**12**
6.	Introduction to data structures, use of pointers in linked structures.	**3**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	H.M. Deitel and P.J. Deitel. C++ How to Program. Prentice Hall, 8th edition.	2011
2.	B. Eckel. Thinking in C++ Volume 1 & 2. Prentice Hall, 2nd edition.	2003
3.	I. Koren. Computer Arithmetic Algorithms. A.K. Peters Ltd., 2nd edition	2001
4.	S.B. Lippman, J. Lajoie, and B.E. Moo. The C++ Primer. Addison-Wesley Professional, 5th edition	2012
5.	S. Oualline. Practical C++ Programming. O'Reilly Media, 2nd edition.	2003
6.	S. Prata. C++ Primer Plus. Sams, 5th edition.	2004
7.	W. Stallings. Computer Organisation and Architecture: Designing for Performance. Prentice-Hall, 7th edition.	2005
8.	B. Stroustrup. The C++ Programming Language. Addison-Wesley, 3rd edition.	1997
9.	R. Lafore. Object-Oriented Programming in C++. Sams Publishing, 4th edition.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-004** Course Title: **Numerical Methods**

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**: Spring** 7. Subject Area**: BSC**

8. Pre-requisite**: Nil**

9. Objective: To introduce various numerical methods to get approximation solutions.

10. Details of Course:

S.No.	Contents	Contact Hours
1	**Error Analysis**: Exact and approximate numbers, Rounding of numbers, Significant digits, Correct digits, various types of errors encountered in computations, Propagation of errors.	**3**
2	**Solution of system of linear equations**: (i) Direct methods: Gauss elimination method without pivoting and with pivoting, LU-decomposition method. (ii) Iterative methods: Jacobi and Gauss-Seidel methods.	**8**
3	Roots of non-linear equations: Bisection method, Regula-Falsi method, Newton-Raphson method, direct iterative method with convergence criteria, Newton-Raphson method for solution of a pair of non-linear equations.	**6**
4	**Eigen values and Eigen vectors**: Dominant and smallest Eigen values/Eigen vectors by power method.	**3**
5	**Interpolation**: Finite difference operator and their relationships, difference tables, Newton, Bessel and Stirling's interpolation formulae, Divided differences, Lagrange interpolation and Newton's divided difference interpolation.	**6**
6	**Numerical differentiation**: First and second order derivatives by various interpolation formulae.	**4**
7.	**Numerical integration:** Trapezoidal, Simpsons $1/3^{rd}$ and $3/8^{th}$ rules with errors and their combinations, Gauss Legendre 2-points and 3-points formulae	**6**
8.	Solution of first and second order ordinary differential equations: Picard's method, Taylor's series method, Euler, Modified Euler, Runge-Kutta methods and Milne's method.	**4**
9.	Case studies	**2**
	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 Edition, Wesley.	2002
2	Jain, M. K., Iyengar, S. R. K. and Jain, R. K., "Numerical Methods for Scientific and Engineering Computation", New Age Pvt. Pub, New Delhi.	2000
3	Conte, S. D. and DeBoor, C., "Elementary Numerical Analysis", McGraw-Hill Publisher	1982
4	Krishnamurthy, E. V. & Sen, S. K., "Applied Numerical Analysis", East West Publication.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-102** 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** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**
8. Pre-requisite**: Nil**
9. Objective: To introduce the basic concepts of vector spaces and linear transformations.
10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Vector Spaces:** Vector space, subspace, sum of subspaces, linear combination, linear dependence and independence, basis and dimension, examples of infinite dimensional spaces, ordered bases and coordinates	10
2	**Linear Transformation:** Basic definitions, rank-nullity theorem, matrix representation, algebra of linear transformations, change of basis, linear functional, Dual Spaces	8
3	**Canonical Forms:** Eigen-values of linear operators, Eigen-space, minimal polynomial, diagonalisation, invariant subspaces, Jordan canonical representation, Norm of a matrix, computation of a matrix exponential	12
4	**Inner Product Space:** Definition of inner product between two vectors, orthogonal and orthonormal vectors, normed space, Gram-Schmidt process for orthogonalisation, projection operator, quadratic forms, positive definite forms, Symmetric, Hermitian, orthogonal, unitary and Normal transformations/matrices.	12
	TOTAL	42

11. Books Recommended:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Hoffman, K. and Kunze, R., "Linear Algebra", 2nd edition, Pearson Education (Asia) Pvt. Ltd/ Prentice Hall of India	2004
2.	Leon, S.J., "Linear Algebra with Applications", 8th Edition, Pearson	2009
3.	Peter, J. Olever and Shakiban, C., "Applied Linear Algebra", 1st Edition , Prentice Hall	2005
4.	Strang, G., "Linear Algebra and its Applications", 3rd edition, Thomson Learning Asia Pvt Ltd	2003
5.	Sudan L., " Applied Linear Algebra ", Prentice Hall	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-104** Course Title: **Real Analysis- I**

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**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

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, Dedekind's theorem, complete ordered field, limit point of a set, Bolzano-Weierstrass theorem, open and closed sets, compact sets and Heine-Borel theorem.	**8**
2.	Sequences, Cauchy's first and second limit theorems, Cauchy sequences, Cauchy criterion for convergent sequences, bounded and monotonic sequences, Euler's constant, subsequences, limit superior and limit inferior. Series of real valued functions and their Tests for convergence.	**6**
3.	Limit and continuity, uniform continuity, monotonic functions, functions of bounded variation, absolutely continuous functions, Taylor's theorem (finite form), Lagrange's form of remainder.	**7**
4.	Sequences and series of real valued functions, their point-wise, absolute and uniform convergence, Cauchy's general principle of uniform convergence, continuity of the limit (sum) function, differentiation and integration of the sequences and series of functions, Weierstrass approximation theorem.	**6**
5.	Riemann integration, Darboux's theorem, necessary and sufficient conditions for integrability, functions defined by integrals, fundamental theorem of calculus, first and second mean value theorems of integral calculus	**8**
6.	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	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Royden. H.L. and Fitzpatrick. P.M., Real Analysis, Prentice Hall India Pvt. Ltd.	2010
2.	Apostol, T. M., Mathematical Analysis, Narosa Publishing House.	2002
3.	Lang. S., Real and Functional Analysis, Springer-Verlag.	1993
4.	Rudin. W., Principles of Mathematical Analysis**,** McGraw-Hill Book Company.	1976
5.	Goldberg, R.R., Methods of Real Analysis, Oxford and IBH Publishing company Pvt. Ltd.	1970

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-106** Course Title: **Data Structures**

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**:** **Spring** 7. Subject Area**: DCC**

6. Pre-requisite**:** **Nil**

9. Objective: To impart the knowledge of basic Data Structures such as Arrays, Stacks, Queues, Linked Lists, Trees, lists and Graphs.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to data structures. Arrays: One and two dimensional arrays, storage allocations. String representation. Implementation of abstract data types (ADT).	**3**
2	Stacks: LIFO structure, push, pop, create, delete and empty stack. Queues: FIFO structure, operations on queues, priority queues, circular queues. Linear lists, list v/s array, internal pointer & external pointer, head, tail of a list, null list, length of a list.	**5**
3	Linked Lists: nodes, linked list data structure, algorithms: insert, delete and retrieve node, create, search, print, append linked list, array of linked lists, header nodes, circularly-linked list, doubly linked list: insertion, deletion.	**8**
4	Binary trees: definition, array, linked and threaded representations, traversal, (Pre, Post and Symmetric order), expression trees (Infix, Prefix and Postfix).	**6**
5	Sorting: Selection sort, bubble sort, exchange sort, quick sort, heap sort and merge sort. Analysis of sorting techniques. Searching: sequential search, binary search, search trees AVL trees, M-way search trees, B trees, hash tables, hashing functions, collision resolution techniques.	**8**
6	General lists: Representations, operations, dynamic storage management, garbage collection, compaction.	**4**
7	Graphs: array and linked representation, operations: add, delete and find vertex, add, delete edge, traverse graph (depth-first, breadth-first). Networks: minimum spanning tree, shortest path algorithm (Dijkstra's algorithm and Kruskal's algorithm).	**8**
	Total	**42**

11. List of Data Structure Practical

Write C++ programs to implement the following:

1. Traversal, insertion, deletion in a linear array.
2. Stacks using arrays.
3. Linear Queue using arrays.
4. Circular Queue using arrays
5. Stacks and Queues using linked list.
6. Singly Linked circular List.
7. Doubly Linked List.
8. Polynomial Arithmetic using linked list.
9. Binary Tree Traversal (pre, post and symmetric order)
10. Sequential Search and Binary Search.
11. Binary Search Tree.
12. Insertion sort, Exchange sort, Selection sort
13. Quick sort.
14. Heap Sort.

12. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Langman, Y., Augenstein, M.; 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	2005
3	Dale N., C++ Plus Data Structures. Narosa Publications.	2000
4	Tenenbaum A. M., Data Structures Using C, Pearson Edn, India.	1990
5	Kruse Robert L., Ryba Alexander J., Data Structures and Program Design in C++	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-201** Course Title: **Complex Analysis-I**

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 knowledge about the analytical aspects of functions of one complex variable.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Algebra of Complex Numbers, inequalities. Stereographic Projection, Topological structure of Complex Plane, Simply connected and multiply connected domains.	**2**
2.	**Analytic Functions**: Functions of a complex variable. Limits, continuity, uniform continuity, differentiability and analyticity of functions, C-R equations, necessary and sufficient conditions, applications to the problems of potential flow, Harmonic functions, Harmonic conjugates, Milne's method. Sequences, Series, Uniform convergence, power series, Hadamard's formula for the radius of convergence, elementary functions, exponential, trigonometric and hyperbolic functions and their identities in the complex plane, multiple valued functions, logarithmic functions and functions with complex exponent.	**10**
3.	**Complex integration:** Rectifiable arcs, contours, complex line integration, Cauchy's theorem for simply and multiply connected domains, Cauchy's integral formula for the derivatives of an analytic function, Winding Numbers, Cauchy's estimate, Morera's theorem, Liouville's theorem, Fundamental theorem of Algebra. Maximum modulus principle, Schwarz Lemma, Taylor series, Laurent series, Zeros and poles of a function, Meromorphic function.	**8**
4.	**Residue Calculus:** The residue at a singularity, Residue theorem, the argument principle, Rouche's theorem, contour integration and its applications to improper integrals, evaluation of a real integrals, improper integrals involving sines and cosines, definite integrals involving sines and cosines, integration through branch cut.	**6**
5.	**Conformal Mapping:** Definition of Conformal and Bilinear transformations, Cross ratio, the mappings from disc to disc, disc to half plane and half plane to half plane. Mapping of elementary transformations.	**7**

6.	**Applications:** Applications of conformal mapping to steady temperature, electrostatic potential, two–dimensional fluid flow, stream function. Schwarz-Christoffel transformations and their applications, Poisson formula, Dirichlet problem in the unit disc, Dirichlet problem in the half plane, Neumann problem for the disc and the half plane.	**9**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors/ Books/Publishers**	**Year of Publication/Reprint**
1.	Churchill, J. W. and Brown, R. V., "Complex Analysis", Mcgraw-Hill.	2009
2.	Gamelin, T. W., "Complex Analysis", Springer-Verlag	2001
3.	Greene R., and Krantz, S. G., "Function Theory of One Complex Variable", 3rd Edition, GSM, Vol. 40, American Mathematical Society.	2006
4.	Kreyszig, E., "Advanced Engineering Mathematics", Wiley, New York	2009
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: **Department of Mathematics**

1. Subject Code: **MAN-202** Course Title: **Transform Techniques**
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**: Spring** 7. Subject Area**: DCC**
8. Pre-requisite**: Nil**
9. Objective: To provide knowledge of various mathematical transformations and their applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Laplace Transform:** Laplace of some standard functions, Existence conditions for the Laplace Transform, Shifting theorems, Laplace transform of derivatives and integrals, Inverse Laplace transform and their properties, Convolution theorem, Initial and final value theorem, Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function, Applications of Laplace transform to solve ODEs and PDEs.	**10**
2.	**Finite Laplace Transform:** Definition and properties, Shifting and scaling theorem.	**5**
3.	**Z-Transform:** Z–transform and inverse Z-transform of elementary functions, Shifting theorems, Convolution theorem, Initial and final value theorem, Application of Z-transforms to solve difference equations.	**5**
4.	**Hankel Transform:** Basic properties of Hankel Transform, Hankel Transform of derivatives, Application of Hankel transform to PDE.	**4**
5.	**Mellin Transform:** Definition and properties of Mellin transform, Shifting and scaling properties, Mellin transforms of derivatives and integrals, Applications of Mellin transform.	**5**
6.	**Fourier series:** Trigonometric Fourier series and its convergence. Fourier series of even and odd functions, Gibbs phenomenon, Fourier half-range series, Parseval`s identity, Complex form of Fourier series.	**5**
7.	**Fourier Transforms:** Fourier integrals, Fourier sine and cosine integrals, Complex form of Fourier integral representation, Fourier transform, Fourier transform of derivatives and integrals, Fourier sine and cosine transforms and their properties, Convolution theorem, Application of Fourier transforms to Boundary Value Problems.	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Kreyszig, E., "Advanced Engineering Mathematics", John Wiley & Sons	2011
2.	Jain, R. K. and Iyenger, S. R. K., "Advanced Engineering Mathematics", Narosa Publishing House	2009
3.	Hildebrand F. B., "Methods of Applied Mathematics", Courier Dover Publications	1992
4.	Debanth L. and Bhatta D., Integal Tranforms and Their Applications, 2nd edition, Taylor and Francis Group	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-203** Course Title: **Discrete Mathematics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory 3** **Practical0**
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 discrete mathematics.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Logic and Proofs: Proposition, predicate logic, logic connectives, methods of proofs. Mathematical induction	**06**
2	Relation and Function: Definitions and properties, pigeonhole principle, extended pigeonhole principle, equivalence relations and equivalence classes. representation of relations by binary matrices and digraphs; operations on relations. closure, Warshall's algorithm, discrete numeric functions, growth of functions, big O, big Θ, hash function.	**10**
3	Partial Order Relations: Partially ordered sets, lattices, isomorphism of lattices	**05**
4	Boolean algebra and Boolean functions, different representations of Boolean functions, application of Boolean functions to synthesis of circuits, circuit minimization and simplification, Karnaugh map.	**08**
5	Languages and grammars, Finite state machines, Finite state automata.	**05**
6	Recurrence Relation: Linear recurrence relations with constant coefficients, homogeneous and non-homogeneous relations, discussion of several special cases to obtain particular solutions. Generating functions, solution of linear recurrence relations using generating functions. Some recursive algorithms.	**08**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Kenneth, K. R., Discrete Mathematics and its Applications, 7th Ed., Tata McGraw Hill,	**2012**
2.	Liu, C. L., Elements of Discrete Mathematics, Tata McGraw Hill	**2007**
3.	Johnsonbaugh, R., Discrete Mathematics, 6th Ed., Maxwell Macmillan International	**2006**
4.	Mott, J.L., Kandel, A. and Baker, T.P., Discrete Mathematics for Computer Scientists and Mathematicians, Prentice Hall India Pvt Ltd	**2001**
5.	Kolman, B., Busby, R. and Ross, S.C., Discrete Mathematical Structure, 6th Ed., Pearson	**2008**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

Name of Department: **Department of Mathematics**

Subject Code: **MAN-204** Course Title: **Database Management Systems**

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**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** A course on Programming languages

9. Objective: To impart the knowledge of basic Data Base Management Systems

10. Details of Course:

S. No.	Contents	Contact Hours
1	Purpose of Database System, Views of data, Data Models, Database Languages-Database System Architecture, Database users and Administrator, Entity Relationship model (E-R model) – E-R Diagrams, Introduction to relational databases.	**8**
2	The relational Model – The catalog Types, Keys, Relational Algebra, Domain Relational Calculus, Tuple Relational Calculus, Fundamental operations, Additional Operations, SQL fundamentals - Integrity, Triggers, Security, Advanced SQL features, Embedded SQL, Dynamic SQL, Missing Information, Views, Introduction to Distributed Databases and Client/Server Databases.	**10**
3	PL/SQL- Basic and Advanced Concepts.	**8**
4	Functional Dependencies – Non-loss Decomposition, Functional Dependencies – First, Second, Third Normal Forms, Dependency Preservation, Boyce/Codd Normal Form, Multi-valued Dependencies and Fourth Normal Form – Join Dependencies and Fifth Normal Form.	**8**
5	Transaction Concepts - Transaction Recovery, ACID Properties, System Recovery, Media Recovery, Two Phase Commit, Save Points – SQL Facilities for recovery, Concurrency, Need for Concurrency, Locking Protocols, Two Phase Locking, Intent Locking, Deadlock, Serializability – Recovery Isolation Levels – SQL Facilities, for Concurrency.	**8**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Silberschatz, A., Korth, H. F., Sudharshan, S., "Database System, Concepts", Sixth Edition, Tata McGraw Hill	2011
2.	Date, C. J., Kannan, A., Swamynathan, S., "An Introduction to Database Systems",Eighth Edition, Pearson Education	2006
3.	Elmasri, R. and Navathe, S. B., "Fundamentals of Database Systems", FourthEdition , Pearson / Addision wesley	2007
4.	Bhattacharya, P. and Majumdar, A., "Introduction to Database Management Systems", Tata McGraw Hill	2001
5.	Desai, B. C., "Introduction to Database Systems" West Group, 11th Ed.	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-205** Course Title: **Ordinary and Partial 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**:** **Nil**

9. Objective: To provide basic concepts of differential equations and their solutions.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Differential Equations:** Formation of differential equations. Basic definitions (linearity, order, homogeneous and non-homogeneous, explicit and implicit solution, general solution, particular solution). Existence and uniqueness theorem for linear ODE.	**3**
2.	**Review of First order ODE:** Separable equations, ODE with homogenous coefficients. Exact equations. Integrating factors. ODE with linear coefficients, Bernoulli equation.	**2**
3.	**Second and Higher order ODE:** Linear independence of functions, Wronskian and its basic properties. Solution of homogeneous and non-homogeneous linear ODE with constant coefficients using method of undetermined coefficients and inverse operator method. Equation with variable coefficients, Euler-Cauchy equations, Variation of parameters, Reduction of order. Solution of second order differential equations by changing dependent and independent variables.	**8**
4.	**Series Solution:** Power series solution of second order homogeneous ODE, ordinary points, singular points, Frobenius series solution, Legendre and Bessel's equation through examples. Elementary properties of Legendre polynomial and Bessel functions.	**9**
5.	**Partial Differential Equations:** Introduction, Curves and surfaces. Formation of PDE, Classification of solutions (Complete, general and singular).	**2**
6.	**First order PDE:** Classification of first order PDE, Lagrange`s method to solve first order PDE. Integral surface passing through a given curve. Compatibility, Charpit's method to solve first order nonlinear PDE. Special types of first order PDE	**9**

7.	**Second order PDE:** Solutions of linear PDE with constant coefficients using differential operators, reducible and irreducible non-homogeneous linear PDE, Homogeneous linear PDE with constant coefficients. Classification of second order PDE, Canonical forms.	**9**
	Total	**42**

11. Suggested Books:

S.No.	**Name of Authors / Books / Publishers**	**Year of Publication/ Reprint**
1	Simmons, G. F. , "Differential Equations " , McGraw-Hill, 2nd Edition	1991
2.	Hildebrand F. B., "Methods of Applied Mathematics", Courier Dover Publications	1992
3.	Tenenbaum, M. and Polard, H., "Ordinary Differential Equations", Dover Publications	1985
4.	Sneddon, I. N., "Elements of Partial Differential Equations", McGraw-Hill Book Company	1988
5.	Rao, K. S., "Introduction to Partial Differential Equations", PHI Learning Pvt. Ltd. (2nd Edition)	2010
6.	Amarnath, T., "An Elementary Course in Partial Differential Equations", Narosa Publishing House (2nd Edition)	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-206** Course Title: **Graph Theory**

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**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **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.	**8**
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.	**7**
5.	**Directed Graphs:** Types of digraphs, digraphs and binary relations, directed paths and connectedness, Euler digraphs, de Brujin sequences, tournaments	**5**
6.	**Ramsey Theory:** Introduction to Ramsey theory, Ramsey numbers, Ramsey theorem.	**3**
7.	**Enumerations:** Types of enumerations, Polya theory of enumeration and its applications.	**5**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
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 Ed.)	2009
3.	Clark J. and Holton J. A.,"A First Look at Graph Theory", World Scientific	1991
4.	Wilson R. J., “Introduction to Graph Theory”, Pearson Education (4th Ed.)	1996
5.	Chartrand G. and Zhang P., "Introduction to Graph Theory", Tata McGraw Hill	2007
6.	Aldous J. M., Wilson R. J. and Best S., “Graphs and Applications: An Introductory Approach”, Springer	2003
7.	Deistel R., “Graph Theory”, Springer (4th Ed.)	2010
8.	Bondy J. A. and Murty U. S. R., “Graph Theory”, Springer	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTR: **Department of Mathematics**

1. Subject Code: **MAN-291** Course Title: **Design and Analysis of Algorithms**

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** 7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce fundamentals of algorithms, their analysis and complexity issues.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Notion of algorithm, pseudo code conventions, Performance analysis, Time and space complexities, Asymptotic notation, Big oh notation, omega notation, theta notation, Average and worst case analysis, Probabilistic analysis, Amortized analysis.	**5**
2.	Recurrence relations, Divide and conquer relations, Solving of recurrences by iteration method and substitution method, Master theorem, Binary search algorithm, Merger sort, Quick sort, Strassen's matrix multiplication method.	**9**
3.	Greedy strategy, Huffman coding algorithm, Data structures of disjoint sets, Complexity analysis of Depth first search, Breadth first search, Prim's algorithm, Kruskal's algorithm, Dijkstra's and Bellman-Ford algorithms, Knapsack problem, Warshall's and Floyd's algorithms.	**12**
4.	Introduction to dynamic programming, Principle of optimality, Optimal binary search trees, Matrix-chain multiplication, Longest common subsequence.	**7**
5.	String matching, The naive string matching algorithm, The Rabin-Karp algorithm	**3**
6.	Introduction to computability, Reducibility, Polynomial-time verification, NP-completeness, NP-complete problems.	**6**
	Total	**42**

11. Suggested References/Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Cormen T. H., Leiserson C. E., Rivest R. L. and Stein C., "Introduction to Algorithms", Prentice Hall India, (3rd Edition)	2004
2.	Aho A. V., Hopcroft J. E. and Ullman J. D., "The Design and Analysis of Computer Algorithms", Pearson Education	2002
3.	Horowitz E., Sahni S. and Rajasekaran S., "Fundamentals of Computer Algorithms", Orient Longman	2006
4.	Kleinberg J. and Tardos E., "Algorithm Design", Pearson Education	2008
5.	Levitin A., "Introduction to the Design and Analysis of Algorithm", (2nd edition) Pearson Education	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-208** Course Title: **Number Theory**
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**: Spring** 7. Subject Area**: DCC**
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, Euclidean algorithm, Linear Diophantine equations, Prime numbers, Fundamental theorem of arithmetic, Prime number theorem (statement only).	**7**
2.	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.	**12**
3.	Quadratic residues, quadratic reciprocity, the Jacobi symbols.	**7**
4.	The greatest integer function, Arithmetic functions, Mobius function and Mobius inversion formula.	**6**
5.	Finite continued fractions, infinite continued fractions, approximation to irrational numbers.	**6**
6.	Introduction to cryptography, public key cryptography, RSA.	**4**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
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.	Andrews G. E., “Number Theory”, Dover Publications	1994
5.	Koblitz N., A Course in Number Theory and Cryptography, Springer (2^{nd} Ed.)	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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 introduce the basic concepts of abstract algebra.

10. Detail of Course:

S. No.	Contents	Contact Hours
1.	Group theory: Definition and some examples of groups, some preliminary lemmas, subgroups, a counting principle, normal subgroups and Quotient groups.	**12**
2.	Homomorphisms, automorphisms, Cayley's theorem, permutation groups, Sylow's theorems.	**11**
3.	Ring theory: Definition and examples of Rings, some special classes of Rings, homomorphisms, Ideal and Quotient rings, Maximal Ideal, Integral domain, Principal Ideal domain, unique factorization domain.	**11**
4.	Definition of field and some examples, the field of Quotients of an Integral domain, Euclidean rings, polynomial rings.	**8**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Herstein, I. N., "Topics in Algebra", 2nd Ed., John Wiley & Sons.	2004
2.	Fraleigh, J. B., "A First Course in Abstract Algebra", 7th Ed., Pearson Education	2003
3.	Dummit, D. S. and Foote, R. M., "Abstract Algebra", 3rd Ed., John Wiley & Sons.	2004
4.	Artin M., "Algebra", 2nd Ed., Prentice Hall India	2011
5.	Gallian J. A., "Contemporary Abstract Algebra", 8th Ed., Cengage Learning	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-302** Course Title: **Mathematical Modeling and Simulation**
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**: Spring** 7. Subject Area**: DCC**
8. Pre-requisite**: Nil**
9. Objective: To develop basic understanding of modeling and simulation techniques.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	What is Mathematical Modeling? History of Mathematical Modeling, latest development in Mathematical Modeling, Merits and Demerits of Mathematical Modeling.	**4**
2.	Introduction to difference equations, Non-linear Difference equations, Steady state solution and linear stability analysis. Introduction to Discrete Models, Linear Models, Growth models, Decay models, Newton's Law of Cooling, Bank Account Problem and mortgage problem, Drug Delivery Problem, Harrod Model of Economic growth, War Model, Lake pollution model, Alcohol in the bloodstream model, Arm Race models, Linear Prey-Predator models, Density dependent growth models with harvesting, Numerical solution of the models and its graphical representation using EXCEL.	**14**
3.	Introduction to Continuous Models, Carbon Dating, Drug Distribution in the Body, Growth and decay of current in a L-R Circuit, Horizontal Oscillations, Vertical Oscillations, Damped Force Oscillation, Dynamics of Rowing, Combat Models, Mathematical Model of Influenza Infection (within host), Epidemic Models (SI, SIR, SIRS, SIC), Spreading of rumour model, Steady State solutions, Linearization and Local Stability Analysis, logistic and gomperzian growth, prey-predator model, Competition models, Numerical solution of the models and its graphical representation using EXCEL.	**14**
4.	Fluid flow through a porous medium, heat flow through a small thin rod (one dimensional), Wave equation, Vibrating string, Traffic flow, Theory of Car-following, Crime Model, Linear stability Analysis: one and two species models with diffusion, Conditions for diffusive instability with examples.	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1.	Albright, B., "Mathematical Modeling with Excel", Jones and Bartlett Publishers.	2010
2.	Marotto, F. R., "Introduction to Mathematical Modeling using Discrete Dynamical Systems", Thomson Brooks/Cole.	2006
3.	Kapur, J. N., "Mathematical Modeling", New Age International	2005
4.	Barnes, B. and Fulford, G. R., "Mathematical Modelling with Case Studies", CRC Press, Taylor and Francis Group.	2009
5.	Edsberg, L., "Introduction to Computation and Modeling for Differential Equations", John Wiley and Sons.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-303** Course Title: **Mathematical Statistics**
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 impart the knowledge of basics of mathematical statistics.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Concept of probability, random variable and distribution function: discrete and continuous distributions, moments and moment generating functions.	**6**
2	Some discrete distributions: Binomial, Poisson, Negative binomial, Geometric, Hypergeometric.	**6**
3	Some continuous distributions: Uniform, Exponential, Gamma, Normal, Lognormal, Beta, Weibull, Cauchy, Pareto.	**8**
4	Bivariate random variables: joint, marginal, conditional distribution. Statistical independence, product moment, correlation, regression, transformation of random variables, distribution of distribution function.	**10**
5	Law of large numbers, central limit theorem.	**04**
6	Simple random sampling with replacement and without replacement, mean and variance of sample mean and variance, parameter and statistics, order statistics and distribution of order statictics, fundamental sampling distribution from normal population viz. χ^2, t, f and Z (central)	**08**
	TOTAL	**42**

12. Suggested Books:

S.No.	Name of Books / Authors/ Publishers	Year of Publication/Reprint
1.	Miller, I. and Miller, M., "Freund's Mathematical Statistics with Applications", Prentice Hall PTR ,7th Ed.	2006
2.	Hogg, R. V. and Craig, A., "Introduction to Mathematical Statistics", Pearson Education, 6th Ed.	2006
3.	Rohatgi, V. K. and Md. Ehsanes Saleh, A. K., "An Introduction to Probability and Statistics", John Wiley and Sons, 2nd edition.	2000
4.	Papoulis, A., Pillai, S.U., Probability, "Random Variables and Stochastic Processes", Tata McGraw-Hill, 4th Ed.	2002
5.	Bhatt B.R., "Modern Probability Theory", New Age International Ltd, 3rd Ed.	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-304** Course Title: **Theory of Computation**

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**: Spring** 7. Subject Area**: DCC**

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

9. Objective: To introduce the theory of automata, languages and grammars.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic definitions, deterministic and non-deterministic finite automata, regular languages, equivalence of deterministic and non-deterministic finite automata, state equivalence and minimization, regular expressions, equivalence of regular expressions and finite automata	**9**
2.	Properties of regular languages, Pumping lemma, Grammars, Types of grammars	**6**
3.	Context-free languages, parse tree, simplifications of context-free grammars, Chomsky normal form, Greibach normal form	**6**
4.	Pushdown automata, deterministic and non-deterministic pushdown automata, equivalence of pushdown automata with context free languages	**6**
5.	Properties of context-free languages, Pumping lemma for context-free languages	**4**
6.	Turing machines, computable languages and functions, modifications of Turing machines	**6**
7.	Computability and decidability, undecidable problems, Halting problem, Complexity classes: P, NP and NP complete	**5**
	Total	**42**

11. Suggested Books**:**

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Hopcroft J. E., Motwani R. and Ullman J. D., "Introduction to automata Theory, languages and Computation", Pearson Education (3rd Ed.)	2008
2.	Sipser M., "Introduction to the Theory of Computation", Course Technology (2nd Ed.)	2012
3.	Lewis H. R. and Papadimitriou C. H., "Elements of the Theory of Computation", Prentice Hall (2nd Ed.)	1998
4.	Linz P., "An Introduction to Formal Languages and Automata", Jones and Bartlett (5th Ed.)	2012
5.	Kozen D., "Automata and Computability", Springer	1997
6.	Cohen D. I. A., "Introduction to Computer Theory", John Wiley & Sons (2nd Ed.)	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-305** Course Title: **Linear Programming**
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 acquaint students with the basic techniques of linear programming.
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, Revised Simplex Method	**11**
3.	Duality Theory, Dual Simplex Method, Sensitivity Analysis, Parametric Linear Programming	**9**
4.	Cutting Plane and Branch and Bound Techniques for all Integer and Mixed Integer Programming Problems,	**5**
5.	Transportation Problems and Assignment Problems	**5**
6.	Graphical Method and Linear Programming Method for Rectangular Games, Saddle point, Notion of Dominance	**5**
7.	CPM/ PERT	**5**
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Taha, H.A., "Operations Research: An Introduction", MacMillan Pub Co., NY, 9th Ed. (Reprint).	2013
2	Mohan, C. and Deep, K., "Optimization Techniques", New Age India Pvt. Ltd, New Delhi.	2009
3	Mittal, K.V. and Mohan, C., "Optimization Methods in System Analysis and Operations Research", New Age India Pvt. Ltd, New Delhi.	1996
4	Ravindran, A., Phillips, D.T. and Solberg, J.J., "Operations Research: Principles and Practice", John Wiley and Sons, NY, 2nd Ed. (Reprint).	2012
5	Pant, J.C., "Introduction to Optimization/Operations Research", Jain Brothers, New Delhi, 2nd Ed.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To introduce the theoretical concepts of ordinary differential equations.

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. Differential and integral inequalities. Fixed point methods.	**9**
2.	Linear systems, properties of homogeneous and non-homogeneous systems, behaviour of solutions of n^{th} order linear homogeneous equations.	**7**
3.	Review of power series, Power series solution of second order homogeneous equations, ordinary points, regular singular points, solution of Gauss hypergeometric equations, Hermite and Chebyshev polynomials.	**8**
4.	Boundary value problems for second order differential equations, Green's function and its applications. Eigen value problems, self adjoint form, Sturm –Liouvile problem and its applications.	**8**
6.	Autonomous systems, phase plane and its phenomenon, critical points and stability for linear and non linear systems, Liapunov's direct method, periodic solutions, limit cycle, the Poincare-Bendixson theorem.	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Braun, M. "Differential Equations and Their Applications", 4th Ed., Springer	2011
2.	Brauer, F. and Nohel, J.A., "The Qualitative Theory of Ordinary Differential Equations", Dover Publications	1989
3.	Coddington E.A., "Ordinary Differential Equations", Tata McGraw Hill	2002
4.	Deo, S.G., Lakshmikantham, V., and Raghvendra, V.,"Text Book of Ordinary Differential Equations", 2nd Ed., Tata McGraw Hill	2010
5.	Simmons G.F., "Ordinary Differential Equations with Applications", Tata McGraw Hill	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-502** Course Title: **Advanced 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**:4** 6. Semester**: Spring** 7. Subject Area**: DCC**
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.	Contents	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.	**Initial Value Problems**: Multistep methods, their error analysis and stability analysis	**6**
3.	**Inverse interpolation:** Their developments and applications	**4**
4.	**Finite Difference**: Review of finite difference operators, finite difference methods.	**2**
5.	**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**
6.	**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: **Department of Mathematics**

1. Subject Code: **MAN-503** Course Title: **Real Analysis-II**
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** 7. Subject Area**: DCC**
8. Pre-requisite**:** **Nil**

9. Objective: To introduce some advanced topics in theory of real functions and metric spaces.

10. Details of 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 Stieltjes integrals, Existence and properties of the integrals, Fundamental theorem of calculus, first and second mean value theorems.	**12**
3.	Introduction to the properties of general measure and measurable spaces, Borel Algebras, complete measure.	**5**
4.	Lebesgue outer measure and measure on the real line, measurable sets and their properties, translation invariance and completeness of Lebesgue measure, Lebesgue integral of a simple function, comparison of Lebesgue and Riemann integrals	**12**
5.	Review of complete metric spaces, compact metric spaces, compactness and uniform continuity and connected metric spaces.	**7**
	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.	Lang, S., "Real and Functional Analysis", Springer-Verlag.	1993
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./CENTR: **Department of Mathematics**

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

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** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To provide an exposure of the advanced topics in rings, modules and Field theory.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Basic concepts of rings, Homomorphism and ideals, Euclidean domains, Principal ideal domains, Unique factorization domains.	**6**
2.	Introduction to modules, Submodules, Quotient modules, Module homomorphism, Simple modules, Cyclic modules, Direct sum of modules, Free modules, Finitely generated modules over principal ideal domains, Fundamental theorem of Abelian groups.	**10**
3.	Modules with chain conditions, Noetherian rings and modules, Hilbert basis theorem, Primary decomposition of ideals in Noetherian rings.	**10**
4.	Field Extensions, Algebraic extensions, Splitting fields and algebraic closures, Normal and separable extensions.	**6**
5.	Introduction to Galois theory, Fundamental theorem of Galois theory.	**6**
6.	Finite fields.	**4**
	Total	**42**

11. Suggested References/Books:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-505** Course Title: **Topology**
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** 7. Subject Area**: DCC**
8. Pre-requisite**: Nil**
9. Objective: To impart the knowledge of the basic concepts of Topology.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Finite, countable, uncountable sets, functions, relations, Axiom of choice, Zorn's Lemma	**2**
2	**Topological Spaces and Continuous functions:** Open sets, closed sets, basis for a topology, Sub basis, T_1 and T_2 Spaces, Order topology, product topology, subspace topology, limit point, continuous function, general product topology, metric space and its Topology, quotient topology	**14**
3	**Connectedness and Compactness:** Connected spaces, connected subspaces, Local connectedness, compact subspace, limit point compactness, Local compactness	**12**
4	**Countability and Separation axiom:** Countability axioms, separation axioms. Regular and Normal Spaces, Urysohn's Lemma, Urysohn metrization Theorem, Tietze Extension Theorem, Tychonoff Theorem	**14**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Munkres, J.R., "Topology", 2nd edition, PHI	2010
2.	Mansfield, M.J., "Introduction to Topology", East-West student Edition	1973
3.	Simmons, G.F., "Introduction to Topology & Modern Analysis", Krieger Publishing Company.	2003
4.	Mendelson, B., "Introduction to Topology," 3rd Ed., Dover Publications	1988
5.	Gamelin, T.W. and Greene, R.E., "Introduction to Topology", 2nd Ed., Dover Publications	1999
6.	Min, Y., "Introduction to Topology: Theory & Applications", Higher Education Press	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-506** Course Title: **Nonlinear Programming**

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**: Spring** 7. Subject Area**: DCC**

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

9. Objective: To introduce the basic techniques of nonlinear programming.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Convex Functions, Karash Kuhn-Tucker Theory, Convex Quadratic Programming, Wolfe's, Beale and Pivot Complementary Algorithm, Separable Programming.	**12**
2	Geometric Programming: Problems with positive co-efficient up-to one degree of difficulty, Generalized method for problems with positive and negative coefficients.	**6**
3	Dynamic Programming: Discrete and continuous Dynamic Programming, Simple illustrations.	**6**
4	Search Techniques: Direct Search and Gradient Methods, Unimodal Functions, Fibonacci Method, Golden Section Method, Method of Steepest Descent, Newton Raphson Method, Hookes and Jeeves Method, Conjugate Gradient Methods.	**11**
5	Constrained optimization: Penalty function approach, Barrier Function Approach.	**2**
6	Multi-objective and Goal Programming.	**5**
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Books/ Authors/ Publishers	Year of Publication
1	Mohan C., Deep, K., "Optimization Techniques", New Age India Pvt. Ltd, New Delhi.	**2009**
2	Mittal K. V., 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, 9th Edition (Reprint).	**2013**
4	Ravindran A, Phillips D. T., 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**
6	Bazaraa, M., Sherali, H. D. and Shetty, C. M., "Nonlinear Programming: Theory and Algorithms", Wiley-Interscience; 3rd Ed.	**2006**
7	Himmelblau, D. M., "Applied Nonlinear Prograaming", Mcgraw-Hill	**1972**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-507** Course Title: **Statistical Inference**
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** 7. Subject Area**: DCC**
8. Pre-requisite**:** : **Nil**
9. Objective: To introduce the concepts of statistical inference.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Principle of Data Reduction: Sufficiency principle, Factorization criterion, minimal sufficiency, Completeness and bounded completeness, Likelihood principle, Equivariance principle.	**08**
2.	Theory of Estimation: Basic concepts of estimation, Point estimation, , methods of estimation; method of moments, method of maximum likelihood; Unbiasedness, Minimum variance estimation, Cramer – Rao bound and its generalization, Rao Blackwell theorem, Existence of UMVUE estimators. Interval Estimation, Some results for normal population case.	**12**
3.	Testing of Hypothesis: Null and alternative hypothesis, Type I and II errors error probability and power function, Method of finding tests, Neyman – Pearson lemma, Uniformly most powerful tests, Likelihood ratio principle, Likelihood ratio test, Sequential probability ratio test, Some results based on normal population.	**18**
4.	Analysis of Variance: one way classification; simple linear regression analysis with normal distribution.	**04**
	TOTAL	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Miller, I. and Miller, M.,"Freund's Mathematical Statistics with Applications", Prentice Hall PTR, 7th edition	2006
2.	Lehman, E.L., "Testing of Statistical Hypothesis", Wiley Eastern Ltd	1959
3.	G. Casella, R. L. Berger, "Statistical Inference", Duxbury Press	2002
4.	Lehman, E.L., "Point Estimation", John Wiley & sons	1984
5.	Rohatgi, V.K., "Statistical Inference", Dover Publications	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-508** Course Title: **Theory of Partial Differential Equations**
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**: DCC**
8. Pre-requisite**:** **Nil**
9. Objective: To provide theoretical concepts of partial differential equations.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Surfaces and curves. Simultaneous differential equations of the first order and first degree. Integral curves of vector fields. Methods of solution of dx/P = dy/Q = dz/R. Orthogonal Trajectories of a system of curves on a surface. Pfaffian differential forms and equations. Solution of Pfaffian differential equations in three variables.	**6**
2.	First Order PDE: Partial differential equations, Origins and classification of first order PDE, Initial value problem for quasi-linear first order equations: Existence and uniqueness of solution, Non-existence and non-uniqueness of solutions. Surfaces orthogonal to a given system of surfaces. Nonlinear PDE of first order, Cauchy method of Characteristics, Compatible systems of first order equations, Charpit's method, Solutions satisfying given conditions. Jacobi's method.	**8**
3.	Second Order PDE: The origin of second order PDE. Equations with variable coefficients, Classification and canonical forms of second order equations in two variables. Classification of second order equations in n variables. Characteristic curves of second order equations in two variables. Importance of characteristic curves.	**5**
4.	Review of Integral Transform and Fourier series.	**2**
5.	Elliptic Equations: Laplace equation in Cartesian, polar, spherical and cylindrical coordinates and its solution by Fourier series method, Poisson equation in 2D. Green's function for Laplace equation, method of Images, eigenfunction method for finding Green's function.	**9**
6.	Hyperbolic Equation: One and two dimensional wave equation, solution by method of characteristics and Fourier series method.	**7**
7.	Parabolic Equations: solution of homogeneous and non-homogeneous diffusion equation (1D). Duhamel's principle.	**5**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Zachmanoglou, E.C., Thoe, D.W., "Introduction to Partial Differential Equattions with Applications", Dover Publications.	1986
2.	Sneddon, I. N., "Elements of Partial Differential Equations", McGraw-Hill Book Company.	1988
3.	Amarnath, T., "An Elementary Course in Partial Differential Equations", Narosa Publishing House (II Edition).	2012
4.	Rao, K. S., "Introduction to Partial Differential Equations", PHI Learning Pvt. Ltd. (2^{nd} Edition).	2012
5.	Lawrence C. Evans, "Partial Differential Equations", American Mathematical Society	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-510** Course Title: **Complex Analysis-II**
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**: DCC**
8. Pre-requisite**: Nil**
9. Objective: To provide advance topics in functions of one complex variable.
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. Revisit to Argument principle, Rouche's theorem.	**5**
2.	**Entire Functions**: Order and genus of entire functions, Hadamard's factorization theorem, coefficient formula for the order, the derived function, exceptional values, Borel's theorem, Little Picard and Great Picard theorem.	**6**
3.	**Harmonic Functions**: Harmonic functions in the disc, Mean Value Property, Maximum and Minimum Principle, Harnack's inequality, Harnack's theorem, The Dirichlet Problem.	**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, Monodromy theorem, Riemann Surfaces,. Homology and homotopy versions of Cauchy's theorem, simply connected regions.	**9**
5.	**Spaces of Analytic functions** Compactness and Convergence, Hurwitz Theorem, Weirstrass factorization theorem, Runge's theorem, Mittag Leffler theorem, Normal families, Equiboundedness, Arzela's theorem	**9**
6.	**Function theory**: Subordination, Riemann mapping theorem, Univalent functions. Gamma function, Riemann zeta function, Riemann hypothesis.	**7**
	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", GSM, Vol. 40, American Mathematical Society, (3^{rd} Ed.)	**2006**
5.	Lang, S., "Complex Analysis", Springer – Verlag.	**2003**
6.	Narasimhan, R. and Nievergelt, Y., "Complex Analysis in One Variable", Birkhauser (2^{nd} Ed.)	**2001**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-601** Course Title: **Fluid Dynamics**

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** 7. Subject Area**: DCC**

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

9. Objective: To introduce basic concepts of fluid dynamics and boundary layer theory

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Lagrangian and Eulerian descriptions, Continuity of mass flow, circulation, rotational and irrotational flows, boundary surface, streamlines, path lines, streak 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, source, sink and doublets, circle theorem, method of images, Theorem of Blasius, Strokes stream function, Motion of a sphere.	**5**
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, Energy equation, Dynamical similarity	**9**
6.	Dimensional analysis, large Reynold's numbers; Laminar boundary layer equations, Similar solutions; Flow past a flat plate, Momentum integral equations, Solution by Karman-Pohlhausen methods, impulsive flow Reyleigh problem, dynamical similarity Thermal boundary layer equation for incompressible flow; Temperature distribution in Coutte flow and in flow past a flat plate.	**5**
7.	Mathematical formulation of the stability problem of incompressible flow, Stability of flows under different cases, Prandtl's momentum transfer theory.	**7**
8	Introduction to Complex fluids.	**4**
	TOTAL	**42**

11. Suggested Books:

S. No.	Title/Authors/Publishers	Year of Publication/ Reprint
1.	Batechelor, G.K., "An Introduction to Fluid Dynamics", Cambridge Press.	2002
2.	Schliting, H. , Gersten K., "Boundary Layer Theory", Springer, 8^{th} edition.	2004
3.	Rosenhead, "Laminar Boundary Layers", Dover Publications	1963
4.	Drazin, P.G., Reid W. H., "Hydrodynamic Stability", Cambridge Press	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **MAN-603** Course Title: **Tensors and Differential Geometry**
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** 7. Subject Area**: DCC**
8. Pre-requisite**:** **Nil**

9. Objective: To provide the basics geometric concepts curves, surfaces and tensors.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Theory of Space Curves:** Space curves, Planer curves, Curvature, Torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.	**8**
2.	**Theory of Surfaces:** Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula, Conjugate and Asymptotic lines.	**9**
3.	**Developables:** Developable associated with space curves and curves on surfaces, Minimal surfaces.	**6**
4.	**Geodesics:** Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem. Surfaces of constant curvature. Conformal mapping. Geodesic mapping. Tissot's theorem.	**9**
5.	**Tensors:** Summation convention and indicial notation, Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different type, Algebra of tensors and contraction, Metric tensor and 3-index Christoffel symbols, Parallel propagation of vectors, Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components.	**10**
	Total	**42**

13. Suggested Books:

S. No.	Title/Authors/Publishers	Year of Publication/ Reprint
1.	Willmore, T. J., "An Introduction to Differential Geometry", Dover publications.	2012
2.	O'Neill B., Elementary Differential Geometry, Academic press, 2nd Ed.	2006
3.	Weatherburn, C.E. Differential Geometry of Three Dimensions, Cambridge University Press (digital pub)	2003
4.	Struik, D., J., "Lectures on Classical Differential Geometry", Dover Publications.	1988
5.	Lang, S., Fundamentals of Differential Geometry, Springer.	1999
6.	Spain, B., "Tensor Calculus: A concise Course", Dover Publications	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Department of Mathematics

1. Subject Code: **MAN-605** Course Title: **Functional 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** 7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To provide the knowledge of Banach space, Hilbert space, Linear transformation , operators and their properties.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Recapitulatisation of Hölder inequality, Minkowski inequality and vector spaces with examples of ℓ_p and L_p spaces.	**2**
2.	Normed linear spaces, Banach spaces with examples, Convergence and absolute convergence of series in a normed linear space.	**4**
3.	Inner product spaces, Hilbert spaces, Relation between Banach and Hilbert spaces. Schwarz inequality.	**2**
5.	Convex sets, Existence and uniqueness of a vector of minimum length, Projection theorem. Orthogonal and orthonormal systems in Hilbert space with examples, Bessel's inequality, Parseval's identity, Characterization of complete orthonormal systems.	**5**
6.	Continuity of linear maps on normed linear spaces, Four equivalent norms on B(N,N`), Conjugate and Dual spaces, The Riesz Representation Theorem.	**5**
7.	Adjoint operators, self adjoint operators, normal operators, Unitary operators on Hilbert spaces (H) and their properties. Isometric isomorphism of H onto itself under Unitary operators and their importance . Projection operators on Banach spaces and Hilbert spaces. Orthogonal Projections.	**9**
8.	Contraction Mappings with examples, Banach–fixed point theorems and applications.	**4**
9.	Eigenvalues, Eigenvectors and Eigen spaces, Invariant spaces, Spectral Theorem on finite dimensional Hilbert spaces.	**4**
10.	The Closed Graph Theorem, The Uniform Boundedness Principle and its applications, The Hahn – Banach Extension and Separation Theorems, Open mapping Theorem and applications	**7**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication/Reprint
1.	Simons, G. F., "Introduction to Topology and Modern Analysis", McGraw Hill.	**2004**
2.	Debnath L. K. and Mikusinski P., "Introduction to Hilbert Spaces with Applications", Academic Press.	**2005**
3.	Bachman G. and Narici L., "Functional Analysis", Academic Press.	**1972**
4.	Ponnusamy S., "Foundation of Functional Analysis", Narosa Publication.	**2002**
5.	Jain P. K. and Ahuja O. P., "Functional Analysis", New Age International Publishers.	**2010**
6.	Nair, M. T., "Functional Analysis: A First Course", PHI Pvt. Ltd.	**2004**