DAV UNIVERSITY JALANDHAR

Course Scheme & Syllabus
For
M.Sc. (Hons.) Mathematics
(Program ID-37)
(As per Choice Based Credit System)

1st to 4th SEMESTER
Examinations 2017–2018 Session Onwards
Syllabi Applicable For Admissions in 2017

M.Sc. (HONS) MATHEMATICS

Semester 1

S.No	Paper Code	Course Type	Course Title	L	T	P	Cr
1	MTH 550	Core	Real Analysis	5	0	0	5
2	MTH 552	Core	Algebra-I	5	0	0	5
3	MTH 553	Core	Linear Algebra	5	0	0	5
4	MTH 554	Core	Classical Mechanics and Calculus of Variations	5	0	0	5
5	Interdisciplinary Course-I						4
Total							24

L: Lectures T: Tutorial P: Practical Cr: Credits

M.Sc. (HONS)MATHEMATICS

Semester 2

S.No	Paper Code	Course Type	Course Title	L	T	P	Cr
1	MTH 555	Core	Complex Analysis	5	0	0	5
2	MTH 556	Core	Theory of Measure and Integration	5	0	0	5
3	MTH 557	Core	Probability and Statistics	5	0	0	5
4	MTH 558	Core	Differential Geometry	5	0	0	5
5	MTH 559	Core	Numerical Analysis	4	0	0	4
6	MTH 561	Core	Numerical Analysis Lab	0	0	4	2
Total							26

L: Lectures T: Tutorial P: Practical Cr: Credits

M.Sc. (HONS) MATHEMATICS

Semester 3

S.No.	Paper Code	Course Type	Course Title	L	T	P	Cr
1	MTH 661	Core	Topology	5	0	0	5
2	MTH 662	Core	Algebra-II	5	0	0	5
3	MTH 663	Core	Ordinary Differential Equations	5	0	0	5
4	Department Elective-I						5
5	Interdisciplinary Course-II						4
	Total						24
Departmental Elective-I(Choose any one course)							
6	MTH 664	Elective	Operations Research-I	5	0	0	5
7	MTH 665	Elective	Fluid Mechanics-I	5	0	0	5
8	MTH 666	Elective	Discrete Mathematics	5	0	0	5

L: Lectures T: Tutorial P: Practical Cr: Credits

M.Sc. (HONS) MATHEMATICS

Semester 4

S.No.	Paper Code	Course Type	Course Title	L	T	P	Cr
1	MTH 667	Core	Functional Analysis	5	0	0	5
2	MTH 668	Core	Number Theory	5	0	0	5
3	MTH 669	Core	Mathematical Methods	5	0	0	5
4	MTH 677	Core	Partial Differential Equations	5	0	0	5
5	Departmental Elective-II**						5
	Total						25
Departmental Elective (Choose any one course)							
6	MTH 671	Elective	Operations Research-II	5	0	0	5
7	MTH 672	Elective	Fluid Mechanics-II	5	0	0	5
8	MTH 673	Elective	Algebraic Topology	5	0	0	5
9	MTH 674	Elective	Category Theory	5	0	0	5

L: Lectures T: Tutorial P: Practical Cr: Credits

**** Students of fourth semester can choose the elective course from the list of elective courses provided below third and fourth semester.**

Course Title: Real Analysis
Paper Code: MTH 550

L	T	P	Credits
5	0	0	5

Objective: The aim of this course is to make the students learn fundamental concepts of metric spaces and Riemann-Stieltjes integral as a generalization of Riemann Integral, the calculus of several variables and basic theorems.

UNIT-I **15HOURS**

Basic Topology: Finite, countable and uncountable sets, metric spaces, compact sets, perfect sets, connected sets.
Sequences and series: Convergent sequences, sub sequences, Cauchy sequences (in metric spaces), completion of a metric space.

UNIT-II **15HOURS**

Continuity: Limits of functions (in metric spaces), continuous functions, continuity and compactness, continuity and connectedness, monotonic functions.
The Riemann-Stieltjes integral: Definition and existence of the Riemann-Stieltjes integral, properties of the integral, integration of vector-valued functions.

UNIT-III **16HOURS**

Sequences and series of functions: Problem of interchange of limit processes for sequences of functions, Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Equicontinuous families of functions, Stone Weierstrass Theorem.

UNIT-IV **14HOURS**

Functions of several variables: Linear Transformations, Differentiation, The contraction principle, The Inverse function theorem. The implicit function theorem.

Reference Books:

1. Rudin, W. *Principles of Mathematical Analysis, 3rd Edition*. New Delhi: McGraw-Hill Inc., 2013.
2. Royden, H. L., and P. M. Fitzpatrick. *Real Analysis, 4th Edition.* New Delhi: Pearson, 2010.
3. Apostol, Tom. *Mathematical Analysis –A modern approach to Advanced Calculus*. New Delhi: Narosa Publishing House, 1957.

Course Title: Algebra-I
Paper Code: MTH 552

L	T	P	Credits
5	0	0	5

Objective: This course provides the foundation required for more advanced studies in Algebra. The aim is also to develop necessary prerequisites for the course MTH 662.

UNIT-I **15 HOURS**

Review of basic property of Groups: Subgroups and cosets, cyclic groups, normal subgroups and quotient groups, Isomorphism theorems. Dihedral groups. Symmetric groups and their conjugacy classes.

UNIT-II **15 HOURS**

Simple groups and their examples, simplicity of An ($n \geq 5$). Normal and Subnormal Series, Derived Series, Composition Series and Solvable Groups.

UNIT-III **16 HOURS**

Cauchy Theorem, Sylow's Theorems and their applications, Converse of Lagrange Theorem, Direct Products, Finite Abelian Groups, Invariants of a finite abelian groups, Groups of order p2, pq. Fundamental Theorem on Finitely generated Abelian Groups.

UNIT-IV **14 HOURS**

Review of Rings, Ring Homomorphism, Ideals, and Algebra of Ideals, Maximal and prime ideals, Ideals in quotient rings, Field of Quotient of Integral domain.

Reference Books:

1. Bhattacharya, P. B., S. K. Jain, and S. R. Nagpaul, *Basic Abstract Algebra, 2nd Edition.* U.K.: Cambridge University Press, 2004.
2. Herstein, I. N. *Topics in Algebra, 2nd Edition*. New Delhi: Wiley, 2006.
3. Singh, Surjeet, and Q. Zameeruddin, *Modern Algebra, 7th Edition*. New Delhi: Vikas Publishing House, 1993.
4. Dummit, David. S., and Richard M. Foote, *Abstract Algebra, 2nd Edition*. New Delhi: Wiley, 2008.

Course Title: Linear Algebra
Paper Code: MTH 553

L	T	P	Credits
5	0	0	5

Objective: The concepts and techniques from linear algebra are of fundamental importance in many scientific disciplines. The main objective is to introduce basic notions in linear algebra that are often used in mathematics and other sciences. The emphasis will be to combine the abstract concepts with examples in order to intensify the understanding of the subject.

UNIT-I **15HOURS**

Vector Spaces, Subspaces, Linear dependence, Basis and Dimensions, Algebra of Linear Transformation, Algebra of Matrices, Row rank, Column rank and their equality, System of Linear Equations.

UNIT-II **15HOURS**

Eigen values and Eigenvectors, Characteristic and minimal polynomials, companion matrix, Cayley Hamilton Theorem, Matrix representation of Linear Transformation, Change of Basis, Canonical forms, Diagonal forms, triangular forms, Rational and Canonical Jordan Forms.

UNIT-III **15HOURS**

Eigen spaces and similarity, Linear functional, Dual Spaces and dual basis, the double dual, Inner Product Spaces, Norms and Distances, Orthonormal basis, The Gram-Schmidt Orthogonalization, Orthogonal complements.

UNIT-IV **15HOURS**

The Adjoint of a Linear operator on an inner product space, Normal and self-Adjoint Operators, Unitary and Normal Operators, Spectral Theorem, Bilinear and Quadratic forms.

Reference Books:

1. Lipschutz, S., and M. Lipson. *Linear Algebra, 3rd Edition*. New Delhi: Tata McGraw Hill, 2011.
2. Hoffman, K., and R. Kunze. *Linear algebra, 2nd Edition.* New Delhi: Prentice Hall, 1971.
3. Axler, S. *Linear Algebra Done Right, 2nd Edition*. New York: Springer Verlag, 2004.
4. Lang, S. *Undergraduate Texts in Mathematics, 3rd Edition*. New York: Springer-Verlag, 2004.

Course Title: Classical Mechanics and Calculus of Variations
Paper Code: MTH 554

L	T	P	Credits
5	0	0	5

Objectives:
The objective of this paper is to introduce the concept of variation of functionals and variational techniques. Dynamics of rigid bodies, Lagrangian and Hamiltonian equations for dynamical systems are also introduced at large.

UNIT-I **16 HOURS**
The variation of a functional and its properties, Fundamental lemma of calculus of variations, Euler's equation for one dependent function and its different forms, Motivational problems of calculus of variation- Shortest distance in a plane, Minimum surface of revolution, Brachistochrone problem, Geodesics, Isoperimetric problems, Functionals involving several dependent variables, Functionals involving higher order derivatives.

UNIT-II **15 HOURS**
Variational problems with moving boundaries, Approximate solutions of Boundary Value Problems- Rayleigh-Ritz method, Galerkin's method, Generalised coordinates, Degree of freedom, Constraints, Holonomic and non-holonomic systems, Generalised velocity, Generalised potential, Generalised force, principle of virtual work, D'Alembert's principle, Lagrange's Equation, Simple applications of the Lagrangian formulation.

UNIT-III **14 HOURS**
Hamiltonian principle, principle of least action, derivation of Lagrange's equations from Hamilton's principle, Legendre transformations, Hamilton's canonical equation of motion, Solving problems using Hamilton's equations, Cyclic co-ordinates, Conservation theorems, Routhian.

UNIT-IV **16 HOURS**
Central force, Equivalent one-body problem, Motion in a central force field, Moments and product of inertia, Theorems of Parallel and Perpendicular axes, Angular momentum of a rigid body about a fixed point and about fixed principal axes, Euler's dynamical equations for motion of rigid body.

Reference Books :

1. Goldstein H., C. Poole, and J. Safko. *Classical Mechanics*. Addison Wesley, 2002.
2. Elsgolts, L. *Differential Equations and the Calculus of Variations*. University Press of the Pacific, 2003.
3. Chorlton F. *Text book of Dynamics*. CBS Publishers, Reprint, 2002.
4. Grantmacher F., *Lecture in analytical Mechanics*. Mir Publication, 1975.
5. Fox, C. *An Introduction to the Calculus of Variation*. New York: Dover Publications, 1987.

Course Title: Complex Analysis
Paper Code: MTH 555

L	T	P	Credits
5	0	0	5

Objective:The objective of the course is to provide foundation for other related branches of Mathematics. Most of the topics covered are widely applicable in Applied Mathematics and Engineering.

UNIT-I **15HOURS**

Complex plane, Stereographic projection, Riemann sphere, Function of complex variables, Continuity and Differentiability, Analytic functions, Conjugate function, Harmonic function, Cauchy Riemann equations (Cartesian and Polar form). Construction of analytic functions. Branch cut and Branch point.

UNIT-II **15HOURS**

Complex line integral, Cauchy's theorem, Cauchy's integral formula and its generalized form. Cauchy's inequality. Poisson's integral formula, Morera's theorem. Liouville's theorem, conformal transformation, bilinear transformation, critical points, fixed points, Cross ratio problems.

UNIT-III **15HOURS**

Meromorphic and entire function. Power series, Taylor's theorem, Laurent's theorem, Maximum modulus theorem (Principle), Schwarz's Lemma, poles and zeroes of meromorphic functions, Argumenta principle, and Fundamental theorem of Algebra and Rouche's theorem.

UNIT-IV **15HOURS**

Zeros, Singularities, Residue at a pole and at infinity. Cauchy's Residue theorem, Jordan's lemma. Integration round Unit Circle. Evaluation of Integrals of the type $\int_C f(z)dz$ where $f(z)$ is a rational function with degree of denominator polynomial greater than that of numerator polynomial by at least two and C is a circle, $\int_0^{2\pi} f(\sin\theta, \cos\theta)d\theta$ and $\int_{-\infty}^{\infty} f(x)dx$.

Reference Books:

1. Copson, E. T. *Theory of functions of complex variables*. U.K.: Oxford University Press, 1970.
2. Ahlfors, L. V. *Complex Analysis 2nd Edition*. New Delhi: McGraw Hill, 1966.
3. Conway, J. B. *Functions of one complex variable*. New York: Springer Verlang, 1978.
4. Churchill, R. V. and J. W. Brown. *Complex Variables and Applications*. New Delhi: Tata McGraw Hill International Edition, 2009.
5. Ponnusamy, S. *Foundation of Complex Analysis, 2nd Edition*. New Delhi: Narosa Publishing House Pvt. Ltd, 2011.
6. Zill, D. G. and P. D. Shanahan. *A First Course in Complex Analysis with Applications*. Massachusetts: Jones and Bartlett Publishers, 2008.

Course Title: Theory of Measure and Integration
Paper Code: MTH 556

L	T	P	Credits
5	0	0	5

Objective:
The objective of this course is to study measure in an abstract setting after having studied Lebesgue measure on real line. The general $\mathbf{L^p}$spaces are also studied.

UNIT-I **15HOURS**

Lebesgue Measure: Introduction, Lebesgue outer measure, Measurable sets, Regularity, Measurable functions, Borel and Lebesgue measurability, Non-measurable sets. Littlewood's three principles.

UNIT-II **15HOURS**

Lebesgue Integral: The Riemann integral, The Lebesgue integral of a bounded function over a set of finite measure, the integral of a non-negative function, The general integral, Convergence and measures.

UNIT-III **15HOURS**

Differentiation and Integration: Differentiation of monotone functions, Functions of bounded variation, differentiation of an integral The Four derivatives, Lebesgue Differentiation Theorem. Absolute continuity. Convex Functions.

UNIT-IV **15HOURS**

The L^P-spaces, Minkowski and Holder inequalities, Convergence and Completeness of L^P spaces, Approximations in L^P spaces, Bounded linear functional on the L^P spaces.

Reference Books:

1. Royden, H. L., and P. M. Fitzpatrick. *Real Analysis, 4th Edition.* New Delhi: Pearson, 2010.

2. Barra, G. de. *Measure Theory and Integration*. New Delhi: Woodhead Publishing, 2011.

Course Title: Probability and Statistics
Paper Code: MTH 557

L	T	P	Credits
5	0	0	5

Objective: The course is designed to equip the students with various probability distributions and to develop greater skills and understanding of Sampling and Estimation.

UNIT-I **15 HOURS**

Random Variables and Distribution Functions: Discrete and continuous random variables, Probability mass, Probability density and cumulative distribution functions, Joint, marginal and conditional distributions, Mathematical expectation, Variance and moments and Moment generating function.

UNIT-II **15 HOURS**

Discrete probability distributions: Bernoulli, Binomial, Poisson, Geometric and Negative Binomial distributions and their properties.

Continuous probability distributions: Uniform, normal, beta distribution of first and second kind, gamma, exponential distributions and their properties.

UNIT-III **15 HOURS**

Sampling Theory: Types of Sampling- Simple, Stratified, Systematic, Errors in sampling, Parameter and Statistics.

Estimation: Unbiasedness, Consistency, Invariant Estimator, Efficient Estimator, Minimum Variance Unbiased Estimators, Characteristics of Estimators, the Method of Maximum Likelihood Estimation,, properties of estimators, confidence intervals.

Exact Sampling Distributions: Chi-square distribution, Student's-t distribution, Snedecor's F-distribution, Fisher's – Z distribution.

UNIT-IV **15 HOURS**

Hypothesis Testing*:* Tests of significance for small samples, Null and Alternative hypothesis, Critical region and level of significance, Tests of hypotheses: most powerful and uniformly most powerful tests, likelihood ratio tests. Tests of significance based on t, Z and F distributions, Chi square test of goodness of fit. Large Sample tests, Sampling of attributes, Tests of significance for single proportion and for difference of proportions, Sampling of variables, tests of significance for single mean and for difference of means and for difference of standard deviations.

Reference Books:

1. Hogg Robert V., JoesephMcKlean, and Allen T Craig. *Introduction to Mathematical Statistics*. London: Pearson Education Limited, 2014.
2. Meyer, P. L. *Introductory Probability and Statistical Applications.* Philippines: Addison-Wesley Publishing Company, 1970.
3. Gupta, S. C., and V. K. Kapoor. *Fundamentals of Mathematical Statistics*.Sultan Chand & Sons: New Delhi, 2002.
4. J.S. Milton and J.C. Arnold, *Introduction to Probability and Statistics,* Fourth Edition, McGraw Hill 2003.
5. Goon, A. M., Gupta, M. K., &Dasgupta, B. *An outline of statistical theory (Vol. 1 & 2)*. World Press Pvt Limited, 2003.
6. Lehmann, E. L., & Casella, G. *Theory of point estimation* (Vol. 31). Springer Science& Business Media, 1998.

Course Title: Differential Geometry
Paper Code: MTH 558

L	T	P	Credits
5	0	0	5

Objective: The objective of this course is to provide knowledge of differential geometry of curves and surfaces in space, with special emphasis on a geometric point of view, as a basis for further study or for applications.

UNIT-I **16 HOURS**

Curves, Arc length, Reparametrization, Level Curves vs Parametrized Curves, Curvature, Plane Curves, Space Curves, Simple Closed Curves, The Isoperimetric Inequality, The Four Vertex Theorem.

UNIT-II **14 HOURS**

Surfaces in three dimensions: Surface, Smooth Surfaces. Tangents, Normals and Orientability. Quadric Surfaces. Triply Orthogonal Systems, Application of Inverse Function Theorem.

UNIT-III **16 HOURS**

The First Fundamental Form: Lengths of Curves on Surfaces, Isometries of Surfaces. Conformal mappings of Surfaces, Surface Area. Equiareal maps and a Theorem of Archimedes. The Second Fundamental Form. The curvature of Curves on a Surface. The Normal and Principal Curvature. Geometrical interpretation of Principal Curvature.

UNIT-IV **14 HOURS**

The Gaussian and Mean Curvatures. The Pseudosphere. Flat Surfaces. Sufaces of constant Mean Curvature. Gaussian Curvature of compact Surfaces. The Gauss Map. Geodesic Equations.

Reference Books:

1. Pressley, Andrew. *Elementary Differential Geometry.* Springer, 2004.
2. Weatherburn, C. E. *Differential Geometry of Three Dimensions*. Nabu Press, 2011.
3. Willmore, T. J. *Introduction to Differential Geometry.* Oxford University Press India, 1997.
4. Berger, M. *A Panoramic View of Riemannian geometry.* Springer, 2003.
5. Prakash, N. *Differential Geometry: An Integrated Approach.* US: McGraw-Hill Inc, 1982.

Course Title: Numerical Analysis
Paper Code: MTH 559

L	T	P	Credits
5	0	0	5

Objective: The objective of this course is to teach methods which are extremely useful in scientific research. The contents of the curriculum have been designed keeping in view the UGC guidelines.

UNIT-I **15 HOURS**

Errors, Error propagation, Order of approximation. Solution of non-linear equations: Bisection, Regula-falsi, Secant, Newton-Raphson, Generalized Newton's method, Chebyshev method, Halley's methods, General iteration method, Muller's method. Rate of convergence. Newton's method for complex roots and multiple roots, Simultaneous non-linear equations by Newton-Raphson method.

UNIT-II **15 HOURS**

Operators: Forward, Backward and Shift (Definitions and some relations among them). Interpolation: Finite differences, divided differences, Newton's formulae for interpolation, Lagrange and Hermite interpolation, Cubic Spline interpolation. Numerical integration-Trapezoidal, Simpson's 1/3rd rule, Simpson's 3/8th rule, Boole's rule, Weddle's rule, Errors in Integration formulae.

UNIT-III **15 HOURS**

Curve fitting: Linear and non-linear curve fitting, curve fitting by sum of exponentials, fitting of exponential Solution of Linear system of equations: Matrix inversion, Gauss-elimination and Gauss-Jordan method, LU decomposition method, Gauss Jacobi and Gauss Seidal method.

UNIT-IV **15 HOURS**

Solution of differential equations: Taylor series method, Euler's method, Modified Euler's method, Runge - Kutta methods of order two, three and four, Predictor – Corrector methods, Finite Difference Method for ODE and PDE (Boundary value problem).

Reference Books:

1. Shastry, S. S. *Introductory Methods of Numerical Analysis*. New Delhi: PHI Learning Private Limited, 2005.
2. Iyenger, S. R. K., R. K. Jain, and Mahinder Kumar. *Numerical Methods for Scientific and Engineering Computation.* Delhi: New Age International Publishers, 2012.
3. Gerald C. F., and P. O. Wheatley. *Applied Numerical Analysis.* India: Pearson Education, 2008.
4. Mathews, John H., and D. Fink Kurtis. *Numerical Methods using Matlab 4th Edition.* New Delhi: PHI Learning Private Limited, 2012.
5. Grewal B. S. *Numerical Methods in Engineering and Science.* New Delhi: Khanna Publishers, 2014

Course Title: Numerical Analysis Lab
Paper Code: MTH 561

L	T	P	Credits
0	0	4	2

Objective: Writing Programs in C/C++ /MATLAB for the problems based on the methods studied in theory paper and to run the Program on PC.

List of Practicals:

(i) To find the absolute value of an integer.
(ii) Bisection Method and error analysis.
(iii) Newton-Raphson Method and error analysis
(iv) Secant Method and error analysis
(v) RegulaFalsi Method and error analysis
(vi) Matrix-inversion method
(vii) Gauss-Jacobi Method.
(viii) Gauss-Seidal Method.
(ix) Calculation of derivatives using Newton interpolation.
(x) Lagrange interpolation.
(xi) Bulle's rule.
(xii) Weddle's rule.
(xiii) Taylor series method.
(xiv) Euler's method.
(xv) Predictor –Corrector methods

Course Title: Topology
Paper Code: MTH 661

L	T	P	Credits
5	0	0	5

Objective: The course is an introductory course on point-set topology so as to enable the reader to understand further deeper topics in topology like Differential/Algebraic Topologies etc.

UNIT-I **15HOURS**

Topological Spaces: examples of topological spaces, the product topology, bases for a topology, the order topology, the box topology, the subspace topology, open sets, closed sets and limit points, continuous functions.

UNIT-II **15HOURS**

The metric topology, the quotient topology, Connectedness: connected spaces, connected subspaces of the real line, components and path components, local connectedness.

UNIT-III **14HOURS**

Compact spaces, compactness in metric spaces, local compactness, T_0, T_1, and T_2 spaces, One-Point Compactification.

UNIT-IV **16HOURS**

Normal spaces, regular spaces, completely regular spaces, the Urysohn Lemma, countability axioms, Stone–Čech compactification, the Tietze Extension Theorem.

Reference Books:

1. Munkers, James R. *Topology*. Delhi: Prentice Hall of India, 2002.
2. Dugundji, J. *Topology*. USA: William C Brown Pub, 1990.
3. *Simmons, G.G. Introduction to Topology and Modern Analysis.* USA: Krieger Publishing Company, 2003.
4. Kelley, J. L. *General Topology*. Van Nostrand: Springer 1975.
5. Joshi, K. D. *Introduction to General Topology.* New Delhi: New Age International, 1983.

Course Title: Algebra-II
Paper Code: MTH 662

L	T	P	Credits
5	0	0	5

Objective: This course is a basic course in Algebra for students who wish to pursue research work in Algebra. Contents have been designed in accordance with the UGC syllabi in mind.

UNIT-I **15HOURS**

Polynomial rings in many variables, factorization of polynomials in one variable over a field. Unique factorization domains, unique factorization in R[x], where R is a Unique Factorization Domain. Euclidean and Principal ideal domain.

UNIT-II **15HOURS**

Gauss Lemma, Eisenstein's Irreducibility Criterion, Fields, Algebraic and Transcendental elements. The degree of a field extension, finite extensions.

UNIT-III **15 HOURS**

Adjunction of roots. Splitting fields. Finite fields. Algebraically closed fields, separable and purely inseparable extensions. Perfect fields.

UNIT-IV **15 HOURS**

Normal extensions, Galois extensions. The fundamental theorem of Galois Theory.

Reference Books:

1. Bhattacharya, P. B., S. K. Jain, and S. R. Nagpaul. *Basic Abstract Algebra, 2nd Edition.* U. K.: Cambridge University Press, 2004.
2. Herstein, I. N. *Topics in Algebra, 2nd Edition*. New Delhi: Wiley, 2006.
3. Singh, Surjeet, and Q. Zameeruddin. *Modern Algebra, 7th Edition*. New Delhi: Vikas Publishing House, 1993.
4. Dummit, David. S., and Richard M. Foote. *Abstract Algebra, 2nd Edition*. Wiley, 2008.

Course Title: Ordinary Differential Equations
Paper Code: MTH 663

L	T	P	Credits
5	0	0	5

Objective: The objective of this course is to equip the students with fundamental knowledge and problem solving skills in Power series methods of solution of ODE, Existence and Uniqueness theory of Initial Value Problems and Solution of system of differential equations.

UNIT-I **14HOURS**

Review of fundamentals of Ordinary differential equations. The method of successive approximation. Initial value problem, Ascoli's Lemma, Gronwall's inequality, Cauchy Peano Existence Theorem, Picard's existence and uniqueness theorem, Lipschitz condition.

UNIT-II **16HOURS**

Linear system of equations (homogeneous & non homogeneous). Superposition principle, Fundamental set of solutions, Fundamental Matrix, Wronskian, Abel Liouville formula, Reduction of order, Adjoint systems and Self Adjoint systems of second order. Linear 2^{nd} order equations, preliminaries, Sturm's separation theorem, Sturm's fundamental comparison theorem.

UNIT-III **15HOURS**

Orthogonal set of functions, Orthonormal set of functions, Gram-Schmidth process of orthonormalization, Sturm Liouville's boundary value problems, Orthogonality of Eigenfunctions and reality of Eigenvalues. Adjoint forms, Lagrange identity, Green function to solve boundary value problems.

UNIT-IV **15HOURS**

Power series solution of differential equation about an ordinary point, Solution about regular singular points: The method of Frobenius, Applications, Legendre's, Hermite's and Bessel's equation. Ordinary differential equations in more than two variables: Simultaneous Differential equations of the first order and the first degree in three variables, Methods of their solution and applications.

Reference Books:

1. Coddington, E. A.*An Introduction to Ordinary Differential Equations*. Prentice-Hall of India Private Ltd., New Delhi, 2001 .
2. Raisinghania, M.D. *Advanced Differential Equations*. New Delhi: S.Chand& Company Ltd. 2001.
3. Piaggio, H. T. H.*Differential Equations*. New Delhi: CBS Publisher, 2004.
4. George, F Simmons.*Differential equations with applications and historical notes*. New Delhi: Tata McGraw Hill, 1974.
5. Sneddon, I. N.*Elements of Partial Differential Equations*. New Delhi: Tata McGraw Hill 1957.
6. Ross, S. L. *Differential Equation*s. New Delhi: John Wiley and Sons 2004.

Course Title: Operations Research-I
Paper Code: MTH 664

L	T	P	Credits
5	0	0	5

Objective: The objective of this course is to acquaint the students with the concept of convex sets, their properties and various separation theorems so as to tackle with problems of optimization of functions of several variables over polyhedron and their duals. The results, methods and techniques contained in this paper are very well suited to the realistic problems in almost every area.

UNIT-I **15HOURS**

Operations Research and its Scope. Necessity of Operations Research in industry. Mathematical formulation of linear programming problem Linear Programming and examples, Convex Sets, Hyper plane, open and closed half-spaces, Feasible, Basic Feasible and Optimal Solutions, Extreme Point & graphical methods. Simple method, Charnes-M method, two phase method, Determination of Optimal solutions, unrestricted variables.

UNIT-II **15HOURS**

Duality theory, Dual linear Programming Problems, fundamental properties of dual Problems, Complementary slackness, unbounded solution in Primal. Dual Simplex Algorithm, Sensitivity analysis.

UNIT-III **15HOURS**

The General transportation problem, transportation table, duality in transportation problem, loops in transportation tables, linear programming formulation, solution of transportation problem, test for optimality, degeneracy, transportation algorithm(MODI method), time minimization transportation problem. Assignment Problems: Mathematical formulation of assignment problem, the assignment method, typical assignment problem, the traveling salesman problem.

UNIT-IV **15HOURS**

Integer Programming: Pure and mixed Integer Programming Problems, Cutting plane techniques, Branch and Bound Technique.
Game Theory: Two-person zero sum games, maxmin-minmax principle, games without saddle points (Mixed strategies), graphical solution of $2 \times n$ and $m \times 2$ games, dominance property, arithmetic method of $n \times n$ games, general solution of $m \times n$ rectangular games.

Reference Books:

1. Taha, H. A. *Operations Research - An Introduction*. New York: Macmillan Publishing Company Inc., 2006.
2. Swarup, K., P.K.Gupta and M. Mohan. *Operations Research.* New Delhi: Sultan Chand & Sons, 2001.
3. Bazaraa, M. S., and S. M. Shetty. *Nonlinear Programming, Theory & Algorithms*. New York: Wiley, 2004.
4. Sinha, S. M. *Mathematical Programming, Theory and Methods*. Delhi: Elsevier, 2006.

Course Title: Fluid Mechanics-I
Paper Code: MTH 665

L	T	P	Credits
5	0	0	5

Objective: The objective of this course is to introduce the fundamentals of modern treatment of incompressible and compressible fluid flows.

UNIT-I **15HOURS**

Real fluids and ideal fluids, velocity of fluid at a point, streamlines, path lines, streak lines, velocity potential, vorticity vector, local and particle rates of change, equation of continuity, incompressible fluid flow, acceleration of fluid, conditions at a rigid boundary.

UNIT-II **15HOURS**

Euler's equation of motion, Bernoulli's equation, their applications, some potential theorems, flows involving axial symmetry- stationary sphere in a uniform stream, impulsive motion, Kelvin's theorem of circulation, equation of vorticity.

UNIT-III **16HOURS**

Some three dimensional flows: sources, sinks and doublets, images in rigid planes, images in solid spheres, Stoke's stream function.

UNIT-IV **14HOURS**

Two dimensional flows: complex velocity potential, Milne Thomson circle theorem and applications, theorem of Blasius, Vortex rows, Karman Vortex Street.

Reference Books:

1. Charlton, F. *Text Book of Fluid Dynamics*.Delhi: GK Publishers, Reprint 2009.
2. Landau, L. D., and E. M. Lifhshitz. *Fluid Mechanics, 2nd Edition*. New-York:Pergamon Press Ltd., 1987.
3. Batchelor, G. K. *An Introduction to Fluid Mechanics*. Cambridge: Cambridge University Press, 1967.
4. Kundu P. K., and I. M. Cohen. *Fluid Mechanics*. Delhi: Harcourt (India) Pvt. Ltd., Reprint 2003.

Course Title: Discrete Mathematics
Paper Code: MTH 666

L	T	P	Credits
5	0	0	5

Objective: The objective of this course is to acquaint the students with the concepts in Discrete Mathematics.It includes the topics like Logics, Graph Theory, Trees and Boolean algebra.

UNIT-I **14 HOURS**

Basic logical operations, conditional and bi-conditional statements, tautologies, contradiction, Quantifiers, prepositional calculus, Recursively defined sequences, the characteristic polynomial. Solution of recurrence relations, generating function.
Counting Techniques: The product rule, the sum rule, the inclusion–exclusion principle, The Pigeonhole Principle and examples. Simple arrangements and selections, Arrangements and selections with repetitions, Distributions, Binomial Coefficients.

UNIT-II **16 HOURS**

Language and Grammars: Computability and Formal Languages, Ordered sets, languages, Phrase structure grammars, Types of grammars and languages, Finite state machines-equivalent machines, Finite state machines as language recognizers, Analysis of algorithm-Time complexity.

UNIT-III **15 HOURS**

Introduction to Graph Theory: Basic Terminology, Special types of Graphs. The Handshaking Theorem, Paths and Circuits Shortest paths. Connectivity of Graphs. Isomorphism of Graphs. Homomorphism Graphs. Eulerian and Hamiltonian Graphs. Planar and Non Planar Graphs. Euler's formula. Graph Colouring. Adjacency and Incidence Matrices. Travelling Salesman
Problem.

UNIT-IV **15 HOURS**

Trees: Basic Terminology. Binary Trees. Tree Traversing: Pre-order, Post-order and In-order Traversals. Minimum Spanning Trees, Prim's and Kruskal's Algorithm.
Boolean algebra, Boolean Function, Switching circuit and Logic Gates, K-map.
Lattice Theory: Lattices and Algebraic Structures, Lattice as algebraic structures, complete lattices, Sub-lattices, Homomorphism on lattices, Modular lattices.
.

Reference Books:

1. Rosen, K. H. *Discrete Mathematics and its Applications.* Delhi: McGraw Hill, 2007.
2. Joshi, K. D. *Foundation of Discrete Mathematics.* Delhi: J. Wiley & Sons, 1989.
3. Malik, D. S., and M. K. Sen. *Discrete Mathematical Structures Theory and Applications.*New Delhi: Thomson Cengage Learning, 2004.
4. Trembley, J. P. and R. P. Manohar. *Discrete Mathematical Structures with Applications toComputer Science.* New Delhi: McGraw Hall, 1975.
5. Liu, C. L. *Elements of Discrete Mathematics.* Delhi: McGraw Hill, 1986.
6. Grimaldi, R. P. *Discrete and Combinatorial Mathematics 5th Edition.* New York: Pearson, 1999.

L	T	P	Credits
5	0	0	5

Course Title: Functional Analysis
Paper Code: MTH 667

Objective: The objective of this course is to introduce basic concepts, methods of Functional Analysis and its Applications. It is a first level course in Functional Analysis.

UNIT-I **14HOURS**

Review of Metric spaces, Holder inequality and Minkowski inequality, Vector spaces with examples, Normed Spaces with examples $l^p, l^\infty, C[a,b]$ etc, Banach Spaces & Schauder Basis, Incomplete normed spaces, Finite Dimensional Normed Spaces and Subspaces, Equivalent norms, Compactness of Metric/ Normed spaces, Riesz's Lemma for two subspaces of a Normed space.

UNIT-II **16HOURS**

Linear Operators- definition and examples, Range and Null space, Inverse Operator, Bounded and Continuous linear operators in a Normed Space, Bounded Linear Functionals in a Normed space with examples, Concept of Algebraic Dual and Reflexive space, Dual basis and Algebraic Reflexive space, Dual spaces with examples.

UNIT-III **17HOURS**

Inner Product and Hilbert space, Further properties of Inner product spaces, Projection Theorem, Orthonormal Sets and Sequences, Fourier Series related to Orthonormal Sequences and Sets, Total Orthonormal Sets and Sequences, Separable Hilbert Spaces, Representation of functionals on a Hilbert Spaces (Riesz's Lemma and Representation), Hilbert Adjoint Operator, Self Adjoint, Unitary & Normal Operators.

UNIT-IV **13HOURS**

Fundamental Theorems for Normed & Banach Spaces: Partially Ordered Set and Zorn's Lemma, Hahn Banach Theorem for Real Vector Spaces, Hahn Banach Theorem for Complex Vector Spaces and Normed Spaces, Baire's Category and Uniform Boundedness Theorems (Banach-Steinhaus Theorem), Open Mapping Theorem, Closed Graph Theorem, Adjoint Operator, Strong and weak convergence, Contraction Theorem.

Reference Books:

1. Kreyzig, E., *Introductory Functional Analysis with Applications*. New York: John Willey and Sons, 1989.
2. Limaye, B. V., *Functional Analysis.* New Delhi: New Age International (P) Ltd, 1996.
3. Rudin, W., *Functional Analysis,* Tata-McGraw Hill Pub. Co.
4. Nair, M. T., *Functional Analysis-A First Course*. New Delhi: Prentice- Hall of India Private Limited, 2008.
5. Simmons, G. F., *Introduction to topology and modern analysis.* New Delhi: Tata McGraw-Hill Education Private Limited, 2012.

Course Title: Number Theory
Paper Code: MTH 668

L	T	P	Credits
5	0	0	5

Objective: The objectives of this course is to teach the fundamentals of different branches of Number Theory, namely, Geometry of Numbers and Analytic Number Theory.

UNIT-I **15HOURS**

Divisibility of Integers, Greatest common divisor, Euclidean algorithm. The Fundamental theorem of Arithmetic, Congruences, Residue classes and reduced residue classes.

UNIT-II **15HOURS**

Chinese remainder theorem, Fermat's little theorem, Wilson's theorem, Euler's theorem. Arithmetic functions σ(n), d(n), τ(n), μ(n), Order of an integer modulo *n*, primitive roots for primes, composite numbers having primitive roots, theory of indices.

UNIT-III **15HOURS**

Quadratic residues, Legendre symbol, Euler's criterion, Gauss's lemma, Quadratic reciprocity law, Jacobi symbol. Perfect numbers, Characterization of even perfect numbers, Elementary results on the distribution of primes, Twin primes, Mersenne primes and Fermat numbers.

UNIT-IV **15HOURS**

Representation of an integer as a sum of two and four squares. Diophantine linear equations *ax+by=c,*Diophantine non-linear equations$x^2 + y^2 = z^2$,$x^4 + y^4 = z^4$. Continued Fractions.

Reference Books:

1. Burton, D.M. *Elementary* Number Theory, 7th Edition. New Delhi: Tata McGraw-Hill 2012.
2. Niven, I., S. Zuckeman, and H. L. Montgomery. *Introduction to Number Theory*. Wiley Eastern 1991.
3. Apostal, T.N. *Introduction to Analytic Number Theory*. Springer Verlag 1976.
4. Hardy, G.H. and E.M. Wright. *An Introduction to the Theory of Number*. U.K: Oxford Univ.

Course Title: Mathematical Methods
Paper Code: MTH 669

L	T	P	Credits
5	0	0	5

Objective: To acquaint the students with the application of Laplace and Fourier Transform to solve Linear Integral Equations.

UNIT-I **15HOURS**

Laplace Transform: Definition, existence and basic properties of the Laplace transform, Inverse Laplace transform, Convolution theorem, Laplace Transform solution of linear differential equation and simultaneous linear differential equation with constant coefficients, Complex inversion formula.

UNIT-II **15HOURS**

Fourier Transform: Definition, existence and basic properties, Inversion formula of Fourier transform Convolution theorem, Parseval's relation. Fourier transform of derivatives and integrals, Fourier sine and cosine transform, Inverse Fourier transform, Solution of linear ordinary differential equations and partial differential equations.

UNIT-III **15HOURS**

Linear integral equations, Special types of kernels, Singular integrals equations, Connection of integral equations with differential equations, Integral equations of the convolution type.

UNIT-IV **15HOURS**

Solution of Fredholm Equations with iterated kernel, Fredholm Equations with general kernel: Solution by the method of successive approximations, adomian decomposition method, Volterra integral equations: Solution by the method of successive approximations, adomian decomposition method.

Reference Books:

1. Moiseiwitsch, B. L. *Integral Equations*. New York: Pitman press, Bath Ltd. 1977.
2. Pinckus, A., and S. Zafrany. *Fourier series and Integral Transform*. New York: Cambridge University Press, 1997.
3. Zemyan, S. M.*The Classical Theory of Integral Equations: A Concise Treatment*. New York: Birkhäuser, 2012.
4. Wazwaz, A. M. *A First Course in Integral Equations.* London: World Scientific, 2015.

Course Title: Partial Differential Equations
Paper Code: MTH 670

L	T	P	Credits
5	0	0	5

Objective: The objective of this course is to introduce the concepts of partial differential equations. To develop analytical techniques to solve partial differential equations. To understand the properties of solution of partial differential equations

UNIT-I **15HOURS**

First Order linear and quasi Partial differential equations, method of Lagrange's, Integral surface through a given curve, Surface orthogonal to given system of surfaces. Nonlinear Partial differential equations of first order, Charpit's Method and Jacobi's Method, Cauchy problem for first order PDE's.

UNIT-II **15 HOURS**

Partial Differential Equations of Second and Higher Order: Origin of second order partial differential equations. Higher order partial differential equations with constant coefficients. Equations with variable coefficients. Classification of second order partial differential equations. Canonical forms. Solution of non-linear second order partial differential equations by Monge's method.

UNIT-III **15HOURS**

Method of Solution: Separation of variables in a PDE; Laplace, wave and diffusion equations, Elementary solutions of Laplace equations.

UNIT-IV **15HOURS**

Applications of PDE: Wave equation, the occurrence of wave equations, elementary solutions of one dimensional wave equation; vibrating membranes, three dimensional problems. Diffusion equation, resolution of boundary value problems for diffusion equation, elementary solutions of diffusion equation.

Reference Books:

1. Sneddon, I. N. *Elements of Partial Differential Equations*. New Delhi: Tata McGraw Hill 1957.
2. Raisinghania, M.D. *Advanced Differential Equations*. New Delhi: S.Chand& Company Ltd. 2001.
3. Piaggio, H. T. H.*Differential Equations*. New Delhi: CBS Publisher, 2004.
4. George, F Simmons.*Differential equations with applications and historical notes*. New Delhi: Tata McGraw Hill, 1974.
5. Ross, S. L. *Differential Equation*s. New Delhi: John Wiley and Sons 2004.

Course Title: Operations Research-II
Paper Code: MTH 671

L	T	P	Credits
5	0	0	5

Objective: To acquaint the students with the concepts of convex and non-convex functions, their properties, various optimality results, techniques to solve nonlinear optimization problems and their duals over convex and non-convex domains.

UNIT-I **15HOURS**

Queuing Theory: Introduction, Queuing System, elements of queuing system, distributions of arrivals, inter arrivals, departure service times and waiting times. Classification of queuing models, Queuing Models**:** (M/M/1): (∞/FIFO), (M/M/1): (N/FIFO), Generalized Model: Birth-Death Process, (M/M/C): (∞/FIFO), (M/M/C) (N/FIFO).

UNIT-II **15HOURS**

Inventory Control: The inventory decisions, costs associated with inventories, factors affecting Inventory control, Significance of Inventory control, economic order quantity (EOQ), and Deterministic inventory problems without shortage and with shortages, EOQ problems with Price breaks, Multi item deterministic problems.

UNIT-III **15HOURS**

Network Analysis-Shortest Path Problem, Minimum Spanning Tree Problem, Maximum Flow Problem, Minimum Cost Flow Problem. Project scheduling by PERT/CPM: Introduction, Basic differences between PERT and CPM, Steps of PERT/CPM Techniques, PERT/CPM network Components and Precedence Relationships, Critical Path analysis, Probability in PERT analysis.

UNIT-IV **15HOURS**

Non Linear Programming –One and Multi Variable Unconstrained Optimization, Kuhn-Tucker Conditions for Constrained Optimization, Quadratic Programming, Separable Programming Convex programming. Non Convex Programming.

Reference Books:

1. Taha, H.A. *Operations Research - An Introduction(8th edition).*New York: Macmillan Publishing Co. 2006.
2. Swarup, K., P.K.Gupta and M. Mohan. *Operations Research.* New Delhi: Sultan Chand & Sons, 2001.
3. Hadly, G.*Non-Linear and Dynamic Programming.* New Delhi:AddisionWesley, Reading Mass. 1967.
4. Rao, S. S.*Optimization theoryand Applications(4th edition).*New Delhi: Wiley Eastern Ltd. 2009.

L	T	P	Credits
5	0	0	5

Course Title: Fluid Mechanics-II
Paper Code: MTH 672

Objective: This course is designed to make the students learn to develop mathematical models of fluid dynamical systems and use mathematical techniques to find solutions to these models.

UNIT-I **16HOURS**

Stress components in a real fluid, relation between Cartesian components of stress, rate of strain quadric and principal stresses, relations between stress and rate of strain, coefficient of viscosity and laminar flow.

UNIT-II **14HOURS**

The Navier-Stokes equations of motion of a viscous fluid, steady motion of viscous fluid between parallel planes, steady flow through tube of uniform circular cross-section, flow through tubes of uniform cross section in the form of circle, ellipse and equilateral triangle.

UNIT-III **14HOURS**

Diffusion of vorticity. Energy dissipation due to viscosity, steady flow past a fixed sphere, dimensional analysis, Reynolds numbers, Prandtl's boundary layer, Karman integral equation.

UNIT-IV **16HOURS**

Elements of wave motion, waves in fluids, Surface gravity waves, standing waves, group velocity, energy of propagations, path of particles, waves at interface of two liquids.

References:

1. Charlton, F. *Text Book of Fluid Dynamics*.Delhi: GK Publishers, Reprint 2009.
2. Landau, L. D., and E. M. Lifhshitz. *Fluid Mechanics, 2nd Edition*. New-York:Pergamon Press Ltd., 1987.
3. Batchelor, G. K. *An Introduction to Fluid Mechanics*. Cambridge: Cambridge University Press, 1967.
4. Kundu P. K., and I. M. Cohen. *Fluid Mechanics*. Delhi: Harcourt (India) Pvt. Ltd., Reprint 2003.

Course Title: Algebraic Topology
Paper Code: MTH 673

L	T	P	Credits
5	0	0	5

Objective: The aim of the unit is to give an introduction to algebraic topology. Algebraic Topology concerns constructing and understanding topological spaces through algebraic, combinatorial and geometric techniques. In particular, groups are associated to spaces to reveal their essential structural features and to distinguish them.

UNIT-I **15HOURS**

The Fundamental group: Homotopy of paths, Homotopy classes, The Fundamental group, change of base point, Topological invariance, covering spaces, The Fundamental group of the circle.

UNIT-II **15HOURS**

Retractions and fixed points, The Fundamental theorem of Algebra, The Borsuk - Ulam theorem, The Bisection theorem, Deformation Retracts and Homotopy type, Homotopy invariance.

UNIT-III **15HOURS**

Direct sums of Abelian Groups, Free products of groups, uniqueness of free products, least normal subgroup, free groups, generators and relations, Van Kampen theorem, also classical version, The Fundamental group of a wedge of circles.

UNIT-IV **15HOURS**

Classification of covering spaces: Equivalence of covering spaces, the general lifting lemma, the universal covering space, covering transformation, existence of covering spaces.

Reference Books:

1. Rotman, J. J. *An Introduction to Algebraic Topology.* New York: Springer, 1988.
2. Hatcher, A. E. *Algebraic Topology.* Cambridge: Cambridge University Press, 2002.
3. Munkres, James R. *Topology*. New Jersey: Prentice Hall, Upper Saddle River, 2000.
4. Dieck, T. T. *Algebraic Topology*. London: European Mathematical Society, 2008.

Course Title: Category Theory
Paper Code: MTH 674

L	T	P	Credits
5	0	0	5

Objective: The objective of this course is to introduce the basic concepts of modern Category Theory.

UNIT-I **15HOURS**

Categories: Introduction with Functions of Sets, Definition and examples of Categories: Sets, Pos, Rel, Mon, Groups, Top, Dis (X), Finite Category, Abstract Mappings, Additive Categories, The category of modules, The concept of functor and the category Cat, Functors of several variables. Isomorhism. Constructions: Product of two categories, The Dual Category, The Arrow Category, The Slice and Co- Slice Category.
Free Categories: Free Monoids and their Universal Mapping Property, The category Graphs, the category C (G) generated by a graph, Homomorphism of Graphs and the Universal Mapping Property of C (g).

UNIT-II **15HOURS**

Abstract Structures:Epis and mono, Initial and Terminal objects, Generalized elements, Sections and Retractions, Product diagrams and their Universal Mapping Property, Uniqueness up to isomorphism, Examples of products: Product of Sets, Product in Cat, Poset, Product in Top. Categories with Products, Hom-Sets, Covariant representable functors, Functors preserving binary product.

UNIT-III **15HOURS**

Duality: The duality principle, Formal duality, Conceptual duality, Coproducts, Examples in Sets, Mon, Top, Coproduct of monoids, of Abelian Groups and Coproduct in the category of Abelian Groups. Equalizers, Equalizers as a monic, Coequalizers, Coequalizers as an epic. Coequalizer diagram for a monoid.
Groups and Categories: Groups in categories, topological group as a group in Top. The category of groups, Groups as categories, Congruence on a category, quotient category and its univalent mapping property, finitely presented categories.

UNIT-IV **15HOURS**

Limits and Co-limits: Subobjects, Pullbacks, Properties of Pullbacks, Pullback as a functor, Limits, Cone to a diagram, limit for a diagram, Co-cones and Colimits. Preservation of limits, contra variant functors. Direct limit of groups. Functors Creating limits and co-limits.

Reference Books:

1. Steven Awodey: Category Theory, (Oxford Logic Guides, 49, Oxford University Press.)