INSTITUTEOFSCIENCE, NAGPUR
(An Autonomous Institute of Government of Maharashtra)

Department of Mathematics
Teaching and Examination scheme
Master of Science Two-Year (Four Semester Degree Course)

M. Sc. Semester- I (Mathematics)											
Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs)			Total Credit	Evaluation Scheme			
				Theory	Tutorial	Practical		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
				Th	Tu	P					
1	DSC	Paper 1:- Real Analysis	M-MT511T	4	--	--	4	3	80	20	40
		Paper 2:- Complex Analysis	M-MT512T	4	--	--	4	3	80	20	40
2	DSE	Elective :-Integral Equations	M-MT511ET	4	--	--	4	3	80	20	40
		Elective :-Integral Transforms	M-MT512ET								
		Elective :- Numerical Analysis	M-MT513ET								
		Elective :- Fuzzy Mathematics	M-MT514ET								
3	LAB		M-MT511P	--	--	12	6	6	100	50	75
4	RM	Research Methodology	M-MT51RM	4	--	--	4	3	80	20	40
Total				16	--	12	22		420	130	--

M. Sc. Semester- II (Mathematics)												
Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs)			Total Credit	Evaluation Scheme			
				Theory	Tutorial	Practical					
				Th	Tu	P		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
1	DSC	Paper 1:- Algebra	M-MT521T	4	--	--	4	3	80	20	40
		Paper 2:- Topology	M-MT522T	4	--	--	4	3	80	20	40
2	DSE	Elective :- Classical Mechanics	M-MT521ET	4	--	--	4	3	80	20	40
		Elective :- Ordinary Differential Equations	M-MT522ET								
		Elective :- Discrete Mathematics	M-MT523ET								
		Elective :- Combinatorics	M-MT524ET								
	LAB		M-MT521P	--	--	12	6	6	100	50	75
3	OJT	Internship / Apprenticeship (Related to DSC)	M-MT52OJT	--	--	8	4	3	80	20	50
Total				12	--	20	22		420	130	--
Cumulative Credits for : PG Diploma in Major Subject = 28, Electives = 8, RM = 4, OJT = 4							44				
Exit option: PG Diploma after Three Year UG Degree :- Cumulative Credits required for PG Diploma (After Three Year Degree) = 44											

M. Sc. Semester- III (Mathematics)

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs) Theory	Tutorial	Practical	Total Credit	Evaluation Scheme Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
				Th	Tu	P					
1	DSC	Paper 1:- Functional Analysis	M-MT531T	4	--	--	4	3	80	20	40
		Paper 2:- General Relativity	M-MT532T	4	--	--	4	3	80	20	40
2	DSE	Elective :- Operation Research-I	M-MT531ET	4	--	--	4	3	80	20	40
		Elective :- Differential Geometry	M-MT532ET								
		Elective :- Field Theory	M-MT533ET								
		Elective :- Fluid Dynamics-I	M-MT534ET								
3	LAB		M-MT531P	--	--	12	6	6	100	50	75
4	RP	Research Project/Dissertation (Core)	M-MT53RP	--	--	8	4	--	80	20	40
Total				16	--	12	22		420	130	--

<table>
<tr><th colspan="13">M. Sc. Semester- IV (Mathematics)</th></tr>
<tr><th rowspan="3">Sr No</th><th rowspan="3">Course Category</th><th rowspan="3">Name of the course
(Title of the Paper)</th><th rowspan="3">Course code</th><th colspan="3">Teaching Scheme (hrs)</th><th rowspan="3">Total Credit</th><th colspan="4">Evaluation Scheme</th></tr>
<tr><th>Theory</th><th>Tutorial</th><th>Practical</th><th rowspan="2">Duration of Examination (Hrs)</th><th rowspan="2">End Semester Evaluation (ESE)</th><th rowspan="2">Continuous Internal Evaluation (CIE)</th><th rowspan="2">Minimum Passing Marks</th></tr>
<tr><th>Th</th><th>Tu</th><th>P</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">DSC</td><td>Paper 1:-Dynamical Systems</td><td>M-MT541T</td><td>4</td><td>--</td><td>--</td><td>4</td><td>3</td><td>80</td><td>20</td><td>40</td></tr>
<tr><td>Paper 2:- Partial Differential Equations</td><td>M-MT542T</td><td>4</td><td>--</td><td>--</td><td>4</td><td>3</td><td>80</td><td>20</td><td>40</td></tr>
<tr><td rowspan="4">2</td><td rowspan="4">DSE</td><td>Elective :- Operation Research-II</td><td>M-MT541ET</td><td rowspan="4">4</td><td rowspan="4">--</td><td rowspan="4">--</td><td rowspan="4">4</td><td rowspan="4">3</td><td rowspan="4">80</td><td rowspan="4">20</td><td rowspan="4">40</td></tr>
<tr><td>Elective :- Cosmology</td><td>M-MT542ET</td></tr>
<tr><td>Elective :- Number Theory</td><td>M-MT543ET</td></tr>
<tr><td>Elective :- Fluid Dynamics-II</td><td>M-MT544ET</td></tr>
<tr><td>3</td><td colspan="2">LAB</td><td>M-MT541P</td><td>--</td><td>--</td><td>12</td><td>6</td><td>6</td><td>100</td><td>50</td><td>75</td></tr>
<tr><td>4</td><td>OJT</td><td>Research Project/Dissertation (Core)</td><td>M-MT54RP</td><td>--</td><td>--</td><td>8</td><td>4</td><td>--</td><td>80</td><td>20</td><td>40</td></tr>
<tr><td colspan="4">Total</td><td>16</td><td>--</td><td>12</td><td>22</td><td></td><td>420</td><td>130</td><td>--</td></tr>
</table>

M. Sc. Part I Semester I Mathematics DSC Paper-I

Course Code & Title:	(M-MT511T) Real Analysis		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Uniform convergence. Uniform convergence and continuity. Uniform convergence and integration. Uniform convergence and differentiation. Equicontinuous families of functions. The Stone-Weierstrass theorem.	By the end of this course, Students will be able to: 1. Understand uniform convergence of sequence of functions. 2. Study utility of uniform convergence in continuity, integration and differentiation. 3. Use inverse function theorem, implicit function theorem, and rank theorem in the advance courses in mathematics. 4. Differentiate between measurable and non measurable sets. 5. Understand general Lebesgue integral. 6. Use Holder and Minkowski inequalities.
II	Linear Transformation. Differentiation. The Contraction Principle. The Inverse Function Theorem. The Implicit Function Theorem. The Rank Theorem. Determinants. Derivatives of Higher Order. Differentiation of Integrals.	
III	Outer measure. Measurable sets and Lebesgue measure. A non-measurable set. Measurable functions. Littlewood's three principles. The Riemann integral. Lebesgue integral of a bounded function over a set of finite measure. Integral of a non-negative function. General Lebesgue integral.	
IV	Differentiation of monotone functions. Functions of bounded variation. Differentiation of an integral. Absolute continuity. Convex functions. L_p-spaces. Holder and Minkowski inequality. Riesz-Fischer theorem. Approximation in L_p. Bounded linear functionals on L_p-spaces.	

Reference Books:

1. Principles of Mathematical Analysis (Third Edition): Walter Rudin Mc GRAW – HILL Book Company.
2. Methods of Real Analysis: R. R. Goldberg, John Wiley.
3. Calculus of Several Variables: C. Goffman, Harper and Row.
4. Real Analysis, H.L. Royden, Third edition, Prentice Hall, 1988.
5. Measure theory and Integration, G. de Barra Wiley Eastern Limited, 1981.
6. An introduction to Measure & Integration, Inder K. Rana, Narosa Publishing House.
7. Linear Algebra (Second Edition), K. Hoffman and R. Kunze, Pearson Publication.

M. Sc. Part I Semester I Mathematics DSC Paper-II

Course Code & Title:	(M-MT512T) Complex Analysis		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

<table>
<tr><th>Unit</th><th>Syllabus</th><th>Course out come</th></tr>
<tr><td>I</td><td>Impossibility of ordering Complex numbers. Elementary properties and examples of analytic Functions: Power series. Analytic functions. Analytic functions as mappings. Mobius transformations.</td><td rowspan="4">By the end of this course, Students will be able to:
1. Represent analytic function as power series.
2. Classify singularities, residues.
3. Apply Cauchy theorem and integral formula.
4. Use open mapping theorem and Goursat theorem.</td></tr>
<tr><td>II</td><td>Power series representation of analytic functions. Zeros of an analytic function. Index of a closed curve. Cauchy’s theorem and integral formula. The homotopic version of Cauchy’s theorem and simple connectivity. Counting zeros; the open mapping theorem. Goursat’s theorem.</td></tr>
<tr><td>III</td><td>Classification of singularities. Laurent series development. Residues. Contour integration. The argument principle. Rouche’s theorem.</td></tr>
<tr><td>IV</td><td>The maximum principle. Schwarz’s lemma. Convex functions and Hadamards three circles theorem. Phragmen-Lindel of theorem.</td></tr>
</table>

Reference Books:

1. Functions of one complex variable: John B. Conway, Second edition, Springer international Student Edition.
2. Complex Analysis, L.V. Ahlfors. Mc-Graw Hill, 1966.
3. Functions of a Complex Variable by Goyal & Gupta, Pragati Prakashan,2010.
4. R. V. Churchil and J. W. Brown: Complex Variables and Applications (5th Edition), McGraw Hill, New York, 1990.
5. Shanti Narayan: Theory of Complex Variables, S. Chand & Co. Ltd., New Delhi.
6. Functions of a Complex Variable by J. N. Sharma, Krishna Prakashan Media (P) Ltd., Meerut.
7. Complex Analysis by A. R. Vasishtha, Krishna’s Educational Publishers.

M. Sc. Part I Semester I Mathematics DSE Paper-I

<table>
<tr><td>Course Code & Title:</td><td colspan="3">(M-MT511ET) Integral Equations</td></tr>
<tr><td>Teaching Hours:</td><td>4 Hours/Week</td><td>Credits:</td><td>4</td></tr>
<tr><td>Total Teaching Hours:</td><td>60 hours</td><td>Max. Marks:</td><td>100 (ESE= 80 + CIE=20)</td></tr>
</table>

<table>
<tr><th>Unit</th><th>Syllabus</th><th>Course out come</th></tr>
<tr><td>I</td><td>Preliminary concepts of integral equations. Some problems which give rise to integral equations. Conversion of ordinary differential equations into integral equations. Classification of linear integral equations. Integro-differential equations.</td><td rowspan="4">By the end of this course, Students will be able to:
1. Convert ordinary differential equation into integral equation.
2. Classify linear integral equations.
3. Do Hermitization and symmetrization of kernels.
4. Solve integral equations.
5. Handle approximate methods of solutions for linear integral equations.</td></tr>
<tr><td>II</td><td>Fredholm equations. Degenerate kernels. Hermitian and symmetric kernels. The Hilbert- Schmidt theorem. Hermitization and symmetrization of kernels. Solutions of integral equations with Green's function type kernels.</td></tr>
<tr><td>III</td><td>Types of Voltera equations. Resolvent kernel of Voltera equations. Convolution type kernels. Some miscellaneous types of Voltera equations. Non-linear Voltera equations. Fourier integral equations. Laplace integral equations.</td></tr>
<tr><td>IV</td><td>Hilbert transform. Finite Hilbert transforms. Miscellaneous integral transforms. Approximate methods of solutions for linear integral equations. Approximate evaluation of Eigen values and Eigen functions.</td></tr>
</table>

Reference Books:

1. Integral Equations: A short course: L. G. Chambers: International text book company Ltd, 1976.
2. Integral equations by Shanti Swaroop, Shiv Raj Singh
3. Linear integral equation, Theory and techniques, Academic press, New York 1971
4. R.P. Kanwal, Linear Integral Equation, Theory and Techniques, Academic Press, N.Y. (1971).
5. S.G. Mikhlin, Linear Integral Equations, Hindustan Book Agency, (1960).
6. A.M. Viazwaz, A First Course in Integral Equations, World Scientific (1997).
7. L.I.G. Chambers, Integral Equation: A Short Course, International Text Book Company Ltd. (1976).
8. Larry Andrews, Bhimsen Shiramoggo, Integral Transform for Engineers, Prentice Hall of India (2003).
9. Integral equations and boundary value problems by M. D. Raisinghania, S. Chand publication

M. Sc. Part I Semester I Mathematics DSE Paper-II

<table>
<tr><td>Course Code & Title:</td><td colspan="3">(M-MT512ET) Integral Transforms</td></tr>
<tr><td>Teaching Hours:</td><td>4 Hours/Week</td><td>Credits:</td><td>4</td></tr>
<tr><td>Total Teaching Hours:</td><td>60 hours</td><td>Max. Marks:</td><td>100 (ESE= 80 + CIE=20)</td></tr>
</table>

<table>
<tr><th>Unit</th><th>Syllabus</th><th>Course out come</th></tr>
<tr><td>I</td><td>Fourier integral theorem. Fourier transforms. Fourier cosine and sine transform. Fourier transforms of derivatives. Fourier transforms of functions. The convolution integral. Parseval’s theorem for cosine and sine transforms. Multiple Fourier transform.</td><td rowspan="4">By the end of this course, Students will be able to:
1. Understand Fourier transform, Fourier sine and cosine transform and their applications to solve partial differential equations and boundary value problems.
2. Understand Mellin transform and their applications to solve integral equations.
3. Understand Hankel transform and their applications to solve partial differential equations.</td></tr>
<tr><td>II</td><td>The solution of integral equations of convolution type. The solution of partial differential equation by means of Fourier transforms. Finite Fourier transforms.</td></tr>
<tr><td>III</td><td>Elementary properties of Mellin transform. Mellin transforms of derivatives and integrals. The Mellin inversion theorem. Convolution theorems for Mellin transform. The solution of some integral equations. Finite Mellin transform.</td></tr>
<tr><td>IV</td><td>Elementary properties of Hankel transform. The Hankel inversion theorem. Hankel transforms of derivatives of functions. The Hankel transforms of some elementary functions. The Parseval relation for Hankel transforms. Relations between Fourier and Hankel transform. The use of Hankel transforms in the solution of partial differential equations. Finite Hankel transforms.</td></tr>
</table>

Reference Books:

1. The use of integral transforms: I N. Sneddon, Tata Mc Graw Hill Publishing Company Ltd.
2. Modern Mathematics For Engineers: Edwin F Beckenbach, Second series, Mc Graw Hill Book Company.

M. Sc. Part I Semester I Mathematics DSE Paper-III

Course Code & Title:	(M-MT513ET) Numerical Analysis		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Simple enclosure methods, Secant method, Newton's method, general theory for one point iteration methods. Aitken extrapolation for linearly convergent sequences, Error tests, Numerical evaluation of multiple roots, roots of polynomials, Mullers method, Non-linear systems of equations, Newton's method for non- linear systems.	By the end of this course, Students will be able to: 1. Apply various methods in numerical analysis to solve algebraic and transcendental equations. 2. Identify roots of the polynomials. 3. Use Newton's method for non-linear systems. 4. Understand Polynomial interpolation. 5. Study approximation problems. 6. Solve Numerical Integration.
II	Polynomial interpolation theory, Newton's divided differences, finite difference and table oriented interpolation formulas. Forward-differences. Hermite interpolation.	
III	The Weierstrass theorem and Taylor's theorem. The minimax approximation problem, the least square approximation problem, orthogonal polynomial, economisation of Taylor series, minimax approximation.	
IV	The trapezoidal rule and Simpson's rule, Newton-Cotes integration formulas.	

Reference Books:

1. An Introduction to Numerical Analysis by K. E. Atkinson, Johan Wiley and sons, Inc.
2. Numerical Analysis by S S Sastry

M. Sc. Part I Semester I Mathematics DSE Paper-IV

Course Code & Title:	(M-MT514ET) Fuzzy Mathematics		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

<table>
<tr><th>Unit</th><th>Syllabus</th><th>Course out come</th></tr>
<tr><td>I</td><td>Uncertainty, Imprecision and Vagueness, Fuzzy systems, Fuzzy Sets, Operations on fuzzy sets, Fuzzy logic, Fuzzy set-theoretic operations, fuzzy relations.</td><td rowspan="4">By the end of this course, Students will be able to:
1. Framework for representing and reasoning with uncertain and imprecise information.
2. Develop a model that can handle ambiguity in data or in decision making process.
3. Extend traditional binary logic to handle degrees of truth.
4. Understand the applications of Fuzzy logic in control systems, expert systems and artificial intelligence.</td></tr>
<tr><td>II</td><td>Membership Functions, Types of Membership Functions, Fuzzy to crisp conversions, Fuzzy arithmetic , Fuzzy numbers, Characterization theorems for Fuzzy numbers, L-R Fuzzy Numbers, Zadeh's Extension Principle, The Sum and Scalar Multiplication, The Product of Two Fuzzy Numbers, Difference of Fuzzy Numbers.</td></tr>
<tr><td>III</td><td>Classical logic and Fuzzy logic, Classical (Crisp) vs, Fuzzy sets, Representation of Fuzzy sets, Sets as Points in Hypercube, Cartesian Product, Crisp and Fuzzy Relations, Basic Concepts (support, singleton, height, a cut projections), Fuzzy set operations, Sand T Norms, Properties of Fuzzy sets.</td></tr>
<tr><td>IV</td><td>Basic Principles of Inference in Fuzzy Logic, Fuzzy IFTHEN Rules, Canonical Form, Fuzzy Systems and Algorithms, Lattice Valued Fuzzy Sets (L-Fuzzy Sets), Intuitionistic Fuzzy Sets . Interval Type II Fuzzy Sets, Fuzzy Sets of Type 2.</td></tr>
<tr><td colspan="3">Reference Books:
1. Barnabas Bede, Mathematics of Fuzzy Sets and Fuzzy Logic, Springer.
2. Timothy J. Ross, Fuzzy Logic with Engineering Applications (Third Edition), Wiley, 2010.
3. Henri Prade, Fuzzy Sets and Systems Theory and Applications: Didier Dubois, Academic Press,1980.</td></tr>
</table>

M. Sc. Part I Semester I Mathematics Practical

Course Code & Title:	LAB (M-MT51P) Based on DSC & DSE		
Teaching Hours:	12 Hours/Week	Credits:	6
Total Teaching Hours:	180 hours	Max. Marks:	150 (ESE= 100 + CIE=50)

M. Sc. Part I Semester I Mathematics Research Methodology

Course Code & Title:	(M-MT51RMT) Research Methodology		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	An Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research,Problems Encountered by Researchers in India.	By the end of this course, Students will be able to: 1. Understand research objectives. 2. Select appropriate research design. 3. Use data collection technique. 4. Use sampling methods. 5. Write research report.
II	Defining the Research Problem: What is a Research Problem? Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration, Conclusion .	
III	Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Conclusion, Appendix: Developing a Research Plan.	
IV	Interpretation and Report Writing: Meaning of Interpretation, Why Interpretation? Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions.	

Reference Books:

1. C.R. Kothari , Gaurav Garg : Research Methodology, Methods and Techniques, NEW AGE International Publishers, Fourth Edition .

2. Soumitro Banerjee, Research Methodology for Natural Sciences, IISc Press, 2022.

M. Sc. Part I Semester II Mathematics DSC Paper-I

Course Code & Title:	(M-MT521T) Algebra		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

<table>
<tr><th>Unit</th><th>Syllabus</th><th>Course out come</th></tr>
<tr><td>I</td><td>Semigroups and groups and examples. Homomorphisms and examples. Subgroups and cosets and examples. Lagrange theorem of finite groups. Problems. Cyclic groups.</td><td rowspan="4">By the end of this course, Students will be able to:
1. Classify between semigroups, groups, permutation groups, dihedral group, Derived group and so on.
2. Use Lagrange theorem.
3. Study groups of order p^n p^2.
4. Find difference between quotient groups and cosets.
5. Study Isomorphism theorem.
6. Study of G-sets and its application in proving Cayley’s theorem and class equation of groups.
7. Study of Normal series, solvable groups and nilpotent groups.
8. Study of alternating group and its simplicity.</td></tr>
<tr><td>II</td><td>Permutation groups. Cayley’s theorem. Groups of symmetries. Dihedral gropus. Normal subgroups. Quotient groups. Commutators in group. Derived group of a group. Isomorphism theorems and examples.</td></tr>
<tr><td>III</td><td>Correspondence theorem. Automorphisms and examples. Conjugacy and G-sets. Cayley’s theorem. Class equation. p-Groups. Burnside theorem. Problems.</td></tr>
<tr><td>IV</td><td>Normal Series. Solvable groups. Nilpotent groups. Permutation groups. Cyclic decomposition of permutation group. Alternating groups A_n. Simplicity of alternating groups A_n. Isomorphism Theorems. Automorphisms. Characteristic subgroup. Conjugacy and G-Sets. Cyclic Decomposition. Alternating group A_n. Simplicity of A_n.</td></tr>
</table>

Reference Books:

1. Basic Abstract Algebra : Bhattacharya, Jain, and Nagpal, Second Edition, Cambridge University Press.
2. Topics in Algebra, I. N. Herstein, Second Edition, John Wiley.
3. Abstract Algebra: David S. Dummit and Richard M. Foote, John Wiley.

M. Sc. Part I Semester II Mathematics DSC Paper-II

Course Code & Title:	(M-MT522T) Topology		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Countable and uncountable sets. Topological Spaces and Examples. Open sets and Limit points. Derived Sets. Closed sets and closure operators. Interior, Exterior and boundary operators. Neighbourhoods. Bases and relative topologies.	By the end of this course, Students will be able to: 1. Determine countable, uncountable sets and cardinal numbers. 2. Describe open sets, derived sets, closed sets and connected set with illustrative examples. 3. Understand compact and countably compact spaces, regular and normal spaces. 4. Identify continuous functions and homeomorphisms. 5. Understand metric topology and product topology. 6. Understand the concept of connectedness, compactness and completeness of topological spaces. 7. Use Urysohn's lemma and Urysohn's metrization theorem.
II	Continuous functions and homeomorphisms. The product topology. The metric topology. The Metrizable spaces.	
III	Connected sets and components. Locally connectedness. Compact and countably compact spaces. Limit Point Compactness. Local Compactness.	
IV	T_0, T_1 and T_2 Spaces. Axioms of countability and Separability. Regular and normal spaces. The Countability Axioms. The separation Axioms. The Urysohn Lemma. The Urysohn metrization Theorem. The Tietz extension theorem.	

Reference Books:

1. Foundations of General Topology: W.J. Pervin, Academic press, 1964.
2. Topology: J.R. Munkres, (second edition), Prentice Hall of India, 2002.
3. Introduction to Topology and Modern Analysis: G.F. Simmons, Mc Graw Hill 1963.
4. General Topology: J.L. Kelley, Van Nostrand, 1995.
5. Introduction to general Topology: K.D. Joshi, Wiley Eastern Ltd. 1983.
6. Topology , J. Dugundji , Prentice Hall of India, New Delhi, 1975.
7. Counter Examples in Topology, L.Steen and J.Subhash, Holt, Rinehart and Winston, New York, 1970.
8. General Topology, S.Willard, Addison - Wesley, Mass., 1970

M. Sc. Part I Semester II Mathematics DSE Paper-I

Course Code & Title:	(M-MT521ET) Classical Mechanics		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Variational principle and Lagranges Equations : Hamilton's principle. some techniques of the calculus of variations. Derivation of Lagrange's Equations from Hamilton's Principle. Extension of principle to nonholonomic systems. Conservation theorems and symmetry properties.	By the end of this course, Students will be able to: 1. Derive Lagrange equations from Hamilton's principle. 2. Describe canonical transformations. 3. Study equations of motions.
II	Legendre transformations and the Hamilton equations of motion. cyclic coordinates and conservation theorems. Routh's equations. Derivation of Hamilton's equations from a Variational principle. the principle of least action.	
III	Canonical transformations. Examples of canonical transformations. Symmetric approach to Canonical Transformation. Poisson's bracket & other canonical invariants.	
IV	Equations of motion. Infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation. The angular momentum Poisson bracket relations. Hamilton-Jacobi theory for Hamilton's principle. and Hamilton-Jacobi theory for characteristic functions.	

Reference Books:

1. H.Goldstein, Classical Mechanics, Second edition, Narosa Publishing House, New Delhi
2. T.M. Karade, G.S.Khadekar, Lectures on Advanced Mechanics, Sonu-Nilu publication
3. A.S.Ramsey Dynamics Part-II, the English Language Book Society and Cambridge University Press.
4. Gupta, Kumar and Sharma, Classical Mechanics
5. I.D. Landau and E.M. Lifchitz, Vol. I third edition, Perguman press, New Delhi
6. N. C. Rana & P .S. Joag ,Classical Mechanics ,Tata Mc Graw Hill
7. L. M. Katkar, Classical Mechanics(Mathematics), Shivaji University Kolhapur, 2007

M. Sc. Part I Semester II Mathematics DSE Paper-II

Course Code & Title:	(M-MT522ET) Ordinary Differential Equations		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Linear Equations with variable coefficients: Initial value problems for the homogeneous equations. Solutions of the homogeneous equations. The Wronskian and linear independence. Reduction of the order of a homogeneous equation. The non-homogenous equations. Homogeneous equations with analytic coefficients. The Legendre equations.	By the end of this course, Students will be able to: 1. The aim of this course is to study basic notions in Differential Equations and use the results in developing advanced mathematics. 2. Solve application problems modeled by linear differential equations and will be able to use power series methods to solve differential equations about ordinary points and regular singular points.
II	Linear Equations with regular singular points: The Euler equations. Second order equations with regular singular points. The Bessel equation. Regular singular points at infinity.	
III	Existence and uniqueness of solutions to first order equations: The method of successive approximations. The Lipschitz condition of the successive approximation. Convergence of the successive approximation. Non-local existence of solutions. Approximations to solutions and uniqueness of solutions.	
IV	Existence and Uniqueness of Solutions to System of first order ordinary differential equations: An example- Central forces and planetary motion. Some special equations. Systems as vector equations . Existence and uniqueness of solutions to systems. Existence and uniqueness for linear systems. Green's function. Sturm Liouville theory.	

Reference Books:

1. E.A.Coddington: An introduction to ordinary differential equations (2012), Prentice Hall of India Pvt.Ltd. New Delhi.
2. G. Birkoff and G.G.Rota: Ordinary Differential equations, John Willey and Sons.
3. Mark Pinsky: Partial differential equations and boundary-value problems with applications, AMS, 3rd edition(2011).
4. G.F. Simmons Differential Equations with Applications and Historical note, MeGraw Hill, Inc. New York. (1972)
5. E.A. Coddington and Levinson: Theory of ordinary differential equations McGraw Hill, New York(1955) .
6. E.D. Rainvills :Elementary differential equations, The Macmillan company, New York. (1964)

M. Sc. Part I Semester II Mathematics DSE Paper-III

Course Code & Title:	(M-MT523ET) Discrete Mathematics		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	**Mathematical Logic:** Introduction, Proposition, compound Proposition, Proposition and truth tables, logical equivalence, algebra of Proposition, conditional Proposition, converse, contra positive & inverse, bi conditional statement, negation of compound statements, tautologies & contradictions, normal forms, logic in proof.	By the end of this course, Students will be able to: 1. Understand Mathematical Logic. 2. Understand partially ordered sets, their properties and lattices. 3. Understand Boolean algebra and Logic Circuits. 4. Understand basic concepts in graph theory.
II	**Lattice:** Lattice as partially ordered sets, their properties, lattices as algebraic system, sub lattices, and some special lattices eg. Complete, complemented and distributive lattices.	
III	**Boolean algebra and Logic Circuits:** Boolean algebra, basic operations, Boolean functions, De-Morgan's theorem, logic gate, sum of products and product of sum forms, normal form, expression of Boolean function as a canonical form, simplification of Boolean expression by algebraic method, Boolean expression form logic & switching network.	
IV	**Graph Theory:** Basic terminology, simple graph, multigraph, degree of a vertex, types of a graph, sub graphs of isomorphic graphs, matrix representation of graphs, Euler's theorem on the existence of Eulerian path & circuits, directed graph, weighted graphs, strong connectivity, chromatic number.	

Reference Books:

1. Discrete Mathematical structures with applications to computer science by J.P. Tremblay and R. Manohar, McGraw-Hill Book Company, 1997.

M. Sc. Part I Semester II Mathematics DSE Paper-IV

Course Code & Title:	(M-MT524ET) Combinatorics		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	**Syllabus**	**Course out come**
I	Two Basic Counting Principles, Simple Arrangements and Selections, Arrangements and Selections with Repetitions, Distributions, Binomial Identities.	By the end of this course, Students will be able to: 1. Use Counting Principles. 2. Determine Coefficients of Generating Functions. 3. Find solutions of Linear Recurrence Relations and Solutions of Non-Homogeneous Recurrence Relations. 4. Understand the concept of Counting with Venn Diagrams.
II	Generating Functions Models, Calculating Coefficients of Generating Functions. Partitions, Exponential Generating Functions, A Summation Method.	
III	Recurrence Relations Models, Divide-and-Conquer Relations, Solutions of Linear Recurrence Relations, Solutions of Non-Homogeneous Recurrence Relations, Solutions of Generating Functions	
IV	Counting with Venn Diagrams, Inclusion-Exclusion Formula, Restricted Positions and Rook Polynomials.	

Reference Books:

1. Alan Tucker: Applied Combinatorics 6th Edn; Wiley India.
2. B. Kolman, R. Busby, S.C. Ross: Discrete Mathematical Structures, 6th Edn, Pearson Edn.
3. Richer A. Brualdi, Introductory Combinatorics, Pearson.

M. Sc. Part I Semester II Mathematics Practical

Course Code & Title:	LAB (M-MT521P) Based on DSC & DSE		
Teaching Hours:	12 Hours/Week	Credits:	6
Total Teaching Hours:	180 hours	Max. Marks:	150 (ESE= 100 + CIE=50)

M. Sc. Part II Semester III Mathematics DSC Paper-I

Course Code & Title:	(M-MT531T) Functional Analysis		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Normed spaces, Banach spaces, Further properties of normed spaces. Finite dimensional normed spaces and subspaces. Compactness and finite dimension. Bounded and continuous linear operators.	By the end of this course, Students will be able to: 1. Define norm on vector space. 2. Study completeness and compactness of normed space. 3. Use different versions of Hahn-Banach theorem. 4. Describe bounded linear operators and closed linear operators.
II	Linear functionals. Normed spaces of operators. Dual spaces. Inner product space. Hilbert space. Further properties of inner product spaces. Orthogonal complements and direct sums. Orthonormal sets and sequences. Total orthonormal sets and sequences.	
III	Representation of functionals on Hilbert spaces. Hilbert adjoint operators, self adjoint, unitary and normal operators. Hahn-Banach Theorem, Hahn-Banach Theorem for complex vector spaces and normed spaces. Reflexive spaces.	
IV	Category theorem, Uniform boundedness theorem, strong and weak convergence, Convergence of sequences of operators and functionals. Open mapping theorem, Closed linear operators and closed graph theorem.	

Reference Books:

1. Introductory Functional Analysis with Applications by E. Kreyszig, John Wiley and Sons.
2. Introduction to Functional Analysis by A.E. Taylor and D.C. Lay, John Wiley and Sons.
3. Introduction to Topology and Modern Analysis: G.F. Simmons, Mc Graw Hill.
4. Linear Algebra (Second Edition), K. Hoffman and R. Kunze, Pearson Publication.

M. Sc. Part II Semester III Mathematics DSC Paper-II

Course Code & Title:	(M-MT532T) General Relativity		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Tensor Algebra, Riemannian geometry, Curvature Tensor: Covariant Curvature tensor, Ricci tensor, Einstein Tensor, The Bianchi identity.	By the end of this course, Students will be able to: 1. Classify tensors. 2. Apply principles of covariance, equivalence and geodesic. 3. Study gravitational field equations. 4. Linearization of field equations.
II	The principle of covariance, the principle of equivalence, Geodesic principle, Newton's equations of motion as an approximation of geodesic equations, Poisson's equations as an approximation to Einstein field equations.	
III	Gravitational field equations in free space, Exterior Schwarzchild's solution and its isotropic form, Birkhoff's theorem, Schwarzchild singularity, planetary orbit, Advance of Perihelion of a planet, Bending of light rays in the gravitational field, Gravitational Red shift in the spectral lines.	
IV	Gravitational field equations for non empty space, Linearization of the field equations, The Weyl's solution of linearized Field equations, Interior Schwarzchild's solution. Newtonian Incompressible star, The pressure contribution mass of static, spherically symmetric System.	

Reference Books:

1. Introduction to General Relativity: Ronald Adler, Maurice Bezinand, Manamen Schiffer, McGraw-Hill Kogakusha Ltd.
2. Introduction to theory of relativity, Rosser W.G.V., ELBS(1972).
3. Lecture on General Relativity, Sonu Nilu Publication (2004) by T M Karade.
4. Relativity Special, General and Cosmology, Rindler W., Pub. Oxford University Press (2003).
5. The Classical Theory of Fields By Landau I. D. and Lifshitz E. M., Pub. Pergamon Press (1978).
6. The Theory of Relativity, Goyal & Gupta.
7. Lecture Notes on General Theory of Relativity, Øyvind Gron (Oyvind Gron) , Springer publication .

M. Sc. Part II Semester III Mathematics DSE Paper-I

Course Code & Title:	(M-MT531ET) Operation Research-I		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Operations Research: Origin, Definition and scope. Linear Programming: Formulation and solution of linear programming problems by graphical and simplex methods, Big - M and two-phase methods, Degeneracy, Duality in linear programming.	By the end of this course, Students will be able to: 1. Identify and develop operations research model describing a real life problem. 2. Understand the mathematical tools that are needed to solve various optimization problems. 3. Solve various linear programming, transportation, assignment, queuing, inventory and game problems related to real life.
II	Transportation Problems: Basic feasible solutions, Optimum solution by stepping stone and modified distribution methods, Unbalanced and degenerate problems, Transhipment problem. Assignment problems: Hungarian method, Unbalanced problem, Case of maximization, Travelling salesman and crew assignment problems.	
III	Concepts of stochastic processes, Poisson process, Birth-death process, Queuing models: Basic components of a queuing system, Steady-state solution of Markovian queuing models with single and multiple servers (M/M/1. M/M/C, M/M/1/k, M/MC/k).	
IV	Inventory control models: Economic order quantity (EOQ) model with uniform demand, EOQ when shortages are allowed, EOQ with uniform replenishment, Inventory control with price breaks.	

Reference Books:

1. Operations Research: Kanti Swarup P.K. Gupta and Man Mohan: Sultan Chand and Sons New Delhi.
2. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
3. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997
4. S. D. Sharma, H. Sharma, Operations Research: Theory, Methods and Applications, Kedar Nath Ram Nath, 1972
5. S. S. Rao, Optimization-Theory and Applications, Wiley Eastern Ltd., 1977.
6. F. S. Hillier, G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001
7. M. S. Bazaraa, H. D. Sherali, C. M. Shetty, Nonlinear Programming-Theory and Algorithms, Wiley-Interscience, 2006
8. A. K. Bhunia and L. Sahoo, Advanced Operations Research, Asian Books Private Limited, New Delhi, 2011.
9. M. Aokie, Introduction to Optimization Techniques: Fundamentals and Applications of Nonlinear Programming, The Macmillan Company, 1971.

M. Sc. Part II Semester III Mathematics DSE Paper-II

Course Code & Title:	(M-MT532ET) Differential Geometry		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Definition of surface. Curves on a surface. Surfaces of revolution. Helicoids. Metric. Direction coefficients. Families of curves. Isometric correspondence. Intrinsic properties.	By the end of this course, Students will be able to: 1. Study canonical geodesic equations. 2. Use properties of geodesics. 3. Difference between Gaussian curvature, constant curvature and mean curvature. 4. Understand compact surfaces and complete surfaces.
II	Canonical geodesic equations, Normal property of geodesics. Existence theorems. Geodesic parallels. Geodesic curvature. Gauss Bonnet theorem. Gaussian curvature. Surfaces of constant curvature. Conformal mapping. Geodesic mapping.	
III	Second fundamental form. Principal curvatures. Lines of curvature. Developable. Developable associated with space curves. Developable associated with curves on surfaces. Minimal surfaces and ruled surfaces. Fundamental equations of Surface theory. Parallel surfaces.	
IV	Compact surfaces whose points are umbilics. Hilbert's lemma. Compact surfaces of constant Gaussian or mean curvature. Complete surfaces. Characterization of complete surfaces. Hilbert's theorem. Conjugate points on geodesics. Intrinsically defined surfaces. Triangulation.	

Reference Books:

1. D. Somasundaram, Differential Geometry: A First Course, Alpha Science International Ltd., Harrow, U.K.
2. T.J. Willmore, An Introduction to Differential Geometry, Oxford University Press, New Delhi.
3. Geometry of curves and surfaces:do Carmo,AcademicPress.

M. Sc. Part II Semester III Mathematics DSE Paper-III

<table>
<tr><td>Course Code & Title:</td><td colspan="3">(M-MT533ET) Field Theory</td></tr>
<tr><td>Teaching Hours:</td><td>4 Hours/Week</td><td>Credits:</td><td>4</td></tr>
<tr><td>Total Teaching Hours:</td><td>60 hours</td><td>Max. Marks:</td><td>100 (ESE= 80 + CIE=20)</td></tr>
</table>

<table>
<tr><th>Unit</th><th>Syllabus</th><th>Course out come</th></tr>
<tr><td>I</td><td>Unique factorization domain. Principal ideals. Euclidean domain. Polynomial rings over unique factorization domains. Problems.</td><td rowspan="4">By the end of this course, Students will be able to:
1. Classify between domain, integral domain, UFD, ED.
2. Use Eisenstein criterion to test the irreducibility of the polynomials.
3. Understand the Galois theory and Fundamental theorem of algebra.
4. Determine the Roots of unity.
5. Understand the limitations of Ruler and compass constructions.</td></tr>
<tr><td>II</td><td>Irreducible polynomials. Eisenstein criterion. Adjunction of roots, Algebraic extensions. Algebraically closed fields. Splitting fields. Normal extensions. Multiple roots. Problems.</td></tr>
<tr><td>III</td><td>Finite fields. Separable extensions. Galois theory . Automorphism groups and Fixed fields. Fundamental theorem of Galois theory. Fundamental theorem of algebra. Problems.</td></tr>
<tr><td>IV</td><td>Roots of unity. Cyclotomic polynomials. Cyclic extensions. Polynomial solvable by radicals. Ruler and compass constructions. Problems.</td></tr>
</table>

Reference Books:

1. Basic Abstract Algebra : Bhattacharya, Jain, and Nagpal, Second Edition, Cambridge University Press.

2. Topics in Algebra, I. N. Herstein, Second Edition, John Wiley.

3. Abstract Algebra: David S. Dummit and Richard M. Foote, John Wiley.

M. Sc. Part II Semester III Mathematics DSE Paper-IV

Course Code & Title:	(M-MT534ET) Fluid Dynamics-I		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Real fluids and ideal fluids, Velocity of a fluid at a point, Stream lines and path lines, Steady and unsteady flows, Velocity potential. Velocity vector, Local and particle rate of change, Equation of continuity, Acceleration of a fluid, Condition at a rigid boundary. General analysis of fluid motion, Euler's equation of motion, Bernoulli's equation, Worked examples, Discussion of the case of steady motion under conservative body forces, Some further aspects of vortex motion.	By the end of this course, Students will be able to: 1. Distinguish between real and ideal fluids, Steady and unsteady fluids. 2. Analyze source, sink and doublets. 3. Understand entropy, Maxwell's thermodynamic relation, Isothermal Adiabatic and Isentropic processes. 4. Understand the equation of motion of a gas. Sonic, subsonic, supersonic flows; isentropic gas flow.
II	Sources, sinks and doublets, Images in a rigid infinite plane and solid spheres, Axisymmetric flows. Stokes' stream function, The complex potential for two-dimensional irrotational, incompressible flow, Complex velocity potential for standard two dimensional flow. Uniform stream, Line source and line sink. Line doublets, Line vortices, Two dimensional image systems, The Milne-Thomson circle theorem, Circle Theorem, Some applications of circle theorem. Extension of circle theorem, The theorem of Blasius.	
III	The equations of state of a substance, the first law of thermodynamics, Internal energy of a gas, functions of state, entropy, Maxwell's thermodynamic relation, Isothermal Adiabatic and Isentropic processes, Compressibility effects in real fluids, the elements of wave motion, One-dimensional wave equation, wave equation in two and three dimensions, spherical waves, progressive and stationary waves.	
IV	The speed of sound in a gas, equation of motion of a gas, Sonic, subsonic, supersonic flows; isentropic gas flow, Reservoir discharge through a channel of varying section, investigation of maximum mass flow through a nozzle. Shock waves, formation of shock waves, elementary analysis of normal shock waves, Navier-Stokes equations of motion of a viscous fluid, Dynamical similarity, Buckingham theorem, Boundary layer equations and boundary layer thickness.	

Reference Books:

1. F. Chorlton, Text book of Fluid Dynamics, CBS Publishers, Delhi 1985.
2. G.K. Batchelor, An Introduction to fluid Mechanics, Foundation Books, New Delhi 1994.
3. M.D. Raisinghania, fluid Mechanics, S. Chand and Company, Delhi.
4. H. Schichting, Boundary layer theory, Mc Graw Hill Book Company, New York 1971

M. Sc. Part I Semester III Mathematics Practical

Course Code & Title:	LAB (M-MT531P) Based on DSC & DSE		
Teaching Hours:	12 Hours/Week	Credits:	6
Total Teaching Hours:	180 hours	Max. Marks:	150 (ESE= 100 + CIE=50)

M. Sc. Part II Semester IV Mathematics DSC Paper-I

Course Code & Title:	(M-MT541T) Dynamical Systems		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Dynamical systems and vector fields. The fundamental theorem. Existence and uniqueness. Continuity of solutions in initial conditions. On extending solutions. Global solutions. The flow of a differential equation.	By the end of this course, Students will be able to: 1. Study various dynamical systems. 2. Apply Poincare-Bendixson theorem. 3. Use Liapunov function. 4. Study gradient systems. 5. Distinguish between stability, asymptotic stability and instability.
II	Nonlinear sinks. Stability. Liapunov function. Gradient systems. Gradients and inner products.	
III	Limit sets, local sections and flow boxes, monotone sequences in planar dynamical systems. The Poincare Bendixson theorem, Applications of Poincare-Bendixson theorem; one species, predator and prey, competing species.	
IV	Asymptotic stability of closed orbits, discrete dynamical systems. Stability and closed orbits. Non Autonomous equations and differentiability of flows. Persistence of equilibria, persistence of closed orbits. Structural stability.	

Reference Books:

1. Differential equations, dynamical systems & linear algebra: M.W. Hirsch & S. Smale, Academic Press, 1975.
2. Dynamical systems: V.I. Arnold, Springer Verlag, 1992.
3. Differential Equations and Dynamical Systems by Lawrence Perko, Springer Publication 3rd Edition.

M. Sc. Part II Semester IV Mathematics DSC Paper-II

Course Code & Title:	(M-MT542T) Partial Differential Equations		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

<table>
<tr><th>Unit</th><th>Syllabus</th><th>Course out come</th></tr>
<tr><td>I</td><td>Curves and surfaces, First order Partial Differential Equations, classification of first order partial differential equations, classifications of Integrals, Linear equations of first order. Pfaffian differential equations, Criteria of Integrability of a Pfaffian differential equation. Compatible systems of first order partial differential equations.</td><td rowspan="4">Upon successful completion of this course, the student will be able to:
1. Classify partial differential equations and transform into canonical form.
2. Solve linear partial differential equations of both first and second order.
3. Solve boundary value problems for Laplace's equation, the heat equation, the wave equation by separation of variables, in Cartesian, polar, spherical and cylindrical coordinates.</td></tr>
<tr><td>II</td><td>Charpits method, Jacobi method of solving partial differential equations, Integral surfaces through a given curve for a linear partial differential equations: Cauchy Problem, Quasi Linear Equations: Geometry of Solutions, Non-linear First Order partial differential equations.</td></tr>
<tr><td>III</td><td>Second order Partial Differential Equations, Classification of second order partial differential equation, Vibration of an infinite string (both ends are not fixed), Physical Meaning of the solution of the wave equation. Vibration of an semi infinite string, Vibration of a string of finite length:(Method of separation of variables), Uniqueness of solution of wave equation. Heat conduction Problems with finite rod and infinite rod.</td></tr>
<tr><td>IV</td><td>Laplace equation, Boundary Value Problems: Dirichlets problems and Neumann problems, Maximum and minimum principles. Dirichlet Problems and Neumann problems for a circle, for a rectangle and for a upper half plane, Families to equipotential surfaces, Solution of Laplace equation, Laplace equation in polar form, Laplace equation in spherical polar coordinates. Kelvin’s inversion theorem, Stability theorem, Duhamel's Principle.</td></tr>
<tr><td colspan="3">Reference Books:
1. T. Amarnath: An elementary course in Partial differential equations, 2nd edition, Narosa publishing House (2012).
2. Mark Pinsky: Partial differential equations and boundary-value problems with applications, AMS,3rd edition(2011).
3. I. N. Sneddon: Elements of Partial Differential Equations, McGraw Hill Int.
4. Fritz John: Partial Differential Equations, Springer(1952).</td></tr>
</table>

M. Sc. Part II Semester IV Mathematics DSE Paper-I

Course Code & Title:	(M-MT541ET) Operation Research-II		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Integer Programming: Gomory's cutting plane algorithm (All integer and mixed integer algorithms), Branch and Bound method.	By the end of this course, Students will be able to: 1. Use Simplex method. 2. Study transportation and assignment problem. 3. Study game theory. 4. To solve game theory problems by using graphical and linear programming methods. 5. Understand basic concept of inventory control.
II	Revised simplex method (with and without artificial variables). Post Optimality Analysis: changes in (i) objective function, (ii) requirement vector, (iii) coefficient matrix; Addition and deletion of variables, Addition of constraints.	
III	Bounded variable technique for L.P.P. Unconstrained optimization, Constrained optimization with equality constraints- Lagrange's multiplier method, Interpretation of Lagrange multiplier.	
IV	Queueing Theory: Basic features of queueing systems, operating characteristics of a queuing system, arrival and departure (birth & death) distributions, inter-arrival and service times distributions, transient, steady state conditions in queueing process. Poisson queueing models- M/M/1, M/M/C for finite and infinite queue length.	

Reference Books:

1. Operations Research: Kanti Swarup P.K. Gupta and Man Mohan: Sultan Chand and Sons New Delhi.
2. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
3. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997
4. S. D. Sharma, H. Sharma, Operations Research: Theory, Methods and Applications, Kedar Nath Ram Nath, 1972.
5. S. S. Rao, Optimization-Theory and Applications, Wiley Eastern Ltd., 1977.
6. F. S. Hillier, G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001
7. M. S. Bazaraa, H. D. Sherali, C. M. Shetty, Nonlinear Programming-Theory and Algorithms, Wiley-Interscience, 2006
8. A. K. Bhunia and L. Sahoo, Advanced Operations Research, Asian Books Private Limited, New Delhi, 2011.
9. M. Aokie, Introduction to Optimization Techniques: Fundamentals and Applications of Nonlinear Programming, The Macmillan Company, 1971.

M. Sc. Part II Semester IV Mathematics DSE Paper-II

Course Code & Title:	(M-MT542ET) Cosmology		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Static cosmological models of Einstein and de Sitter and their derivation and its Properties: (i) The geometry of the Universe (ii) Density and pressure (iii) Motion of test particle (iv) Doppler shift (v) comparison with actual universe, Comparison between Einstein and de-Sitter models.	By the end of this course, Students will be able to: 1. Compare cosmological models of Einstein and de Sitter. 2. Derive Robertson Walker metric and its properties. 3. Study fundamental theorem of dynamical cosmology. 4. Study cosmological principle.
II	Cosmological principle, Hubble law, Weyl's postulate, Derivation of Robertson Walker Metric and its properties, Motion of a particle and light rays in FRW model, Red shift, Deceleration parameter and Hubble's constant, Matter Dominated era.	
III	Friedman Model, Fundamental equation of dynamical cosmology, density and pressure of the present universe, Matter dominated era of the universe, critical density, flat, closed and open universe, age of the universe.	
IV	Steady state cosmology, Distance measure in cosmology, Commoving distance, Apparent luminosity and luminosity distance, Angular diameter and Lookback time, Horizons and the Hubble radius; Galaxy count, the Particle horizons, the Event Horizon.	

Reference Books:

1. Relativity, Thermodynamics and Cosmology: Richard C. Tolman, Oxford Press
2. Gravitation and Cosmology : Principles and Applications of the General Theory of Relativity by Steven Weinberg.
3. The Classical Theory of Fields, By Landau I.D. and Lifshitz E.M., Pub. Pergamon Press (1978).
4. Lecture on General Relativity , Sonu Nilu Publication (2004) by T M Karade, G S Khadekar and Maya S Bendre
5. The Theory of Relativity Moller C, Pub. Oxford University Press (1982).
6. Introduction to theory of relativity, Rosser W.G.V., ELBS (1972).
7. Relativity Special, General and Cosmology, Rindler W., Pub. Oxford University Press (2003).
8. Relativity: The General Theory, Synge J.L., North Holland Pub. Comp. (1971).

M. Sc. Part II Semester IV Mathematics DSE Paper-III

Course Code & Title:	(M-MT543ET) Number Theory		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	**Syllabus**	**Course out come**
I	The Mobius function u(n), The Arithmetic functions, The Euler totient function $\varphi(n)$, A relation connecting φ and μ. A product formula for φ (n), The Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius Inversions formula. Multiplicative functions and Dirichlet multiplication, The divisor function (n).	By the end of this course, Students will be able to: 1. Understand the concept of Mobius function u(n), Euler totient function $\varphi(n)$. 2. Understand Euler's summation formula, asymptotic formulas, the average order of d(n), the average order of divisor functions (n), the average order of $\varphi(n)$. 3. Understand Chebyshev's functions $\Psi(x)$ and v(x) and their relations. 4. Understand reduced residue systems and Euler-Format theorem, Polynomial congruences modulo-p.
II	Introduction, The big oh notation Asymptotic equality of functions, Euler's summation formula, some elementary asymptotic formulas, the average order of d(n), the average order of divisor functions (n), the average order of $\varphi(n)$, An application to the distribution of lattice points visible from the origin. The average order of $\mu(n)$ and $\pi(n)$, The partial sums of a Dirichlet product, Applications to $\mu(n)$ and $\pi(n)$, Another identity for the partial sums of a Dirichlet product.	
III	Introduction, Chebyshev's functions $\Psi(x)$ and v(x). Relations connecting Ψ (x) and v(x), some equivalent forms of the prime number theorem, Inequalities of $\pi(n)$ and Pn Shapiro's Tauberian theorem. Application of Shapiro's theorem. An asymptotic formula for the partial sums $\Sigma (1/p)$.	
IV	Definition and basic properties of congruences. Residue classes and complete residue systems. Linear congruences. Reduced residue systems and Euler - Format theorem, Polynomial congruences modulo p, Lagrange's theorem. Simultaneous linear congruences, the Chinese remainder theorem. Applications of the Chinese remainder theorem. Polynomial congruences with prime power moduli.	

Reference Books:

1. Introduction to analytic number theory - by Tom M-Apostol, Narosa Publishing House, New Delhi.
2. Introduction to the theory of numbers-by Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomer, John Wiley & Sons, Inc , 5th Edition.
3. Elementary Number Theory by David M. Burton (Seventh Edition): Tata McGraw-Hill Edition, New Delhi (2012)
4. Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Limited, Delhi, 2007.
5. George E Andrews, Number Theory, Hindustan Publishing Corporation, 1984.

M. Sc. Part II Semester IV Mathematics DSE Paper-IV

Course Code & Title:	(M-MT544ET) Fluid Dynamics-II		
Teaching Hours:	4 Hours/Week	Credits:	4
Total Teaching Hours:	60 hours	Max. Marks:	100 (ESE= 80 + CIE=20)

Unit	Syllabus	Course out come
I	Stress components in a real fluid, relation between Cartesian components of stress translation motion of fluid elements, the rate of strain quadric and principal stresses, some further properties of the rate of the strain quadric, stress analysis in fluid motion, relation between stress and rate of strain, the coefficient of viscosity and laminar flow, the Navier-Stokes equations of motion of a viscous fluid, some solvable problems in viscous flow, diffusion of vorticity, energy dissipation due to viscosity, steady flow past a fixed sphere.	By the end of this course, Students will be able to: 1. Understand Stress components in a real fluid. 2. Understand Navier-Stokes equations of motion of a viscous fluid. 3. Understand Maxwell electromagnetic field equations. 4. Understand dynamical similarity, Buckingham Theorem, Renold number. 5. Understand turbulence theory.
II	Nature of magneto-hydrodynamics, Maxwell electromagnetic field equations; Motion at rest, Motion in medium , Equation of motion of conducting fluid, Rate of flow of charge, Simplification of electromagnetic field equation. Magnetic Reynold number; Alfven's theorem, The magnetic body force. Ferraro's Law of Isorotation.	
III	Dynamical similarity, Buckingham Theorem. Renold number. Prandtl's boundary layer, Boundary layer equation in two dimensions, Blasius solutions, Boundary layer thickness, Displacement thickness. Karman integral conditions, Separation of boundary layer flow.	
IV	Turbulence: Definition of turbulence and introductory concepts. Equations of motion for turbulent flow. Reynolds Stresses Cylindrical coordinates. Equation for the conservation of a transferable scalar quantity in a turbulent flow. Double correlations between turbulence-velocity components. Change in double velocity correlation with time. Introduction to triple velocity correlations. Features of the double longitudinal and lateral correlations in a homogeneous turbulence. Integral scale of turbulence.	

Reference Books:

1. Text book of Fluid Dynamics: F. Chorlton; CBS Publishers, Delhi 1985.
2. Fluid Mechanics: Joseph Spurk; Springer.
3. Turbulence by J.O. Hinze, 2nd edition, Mc Graw-Hill, chapter 1 sections 1.1 to 1.7
4. Fluid Mechanics by M.D. Raisinghania, S. Chand and Company, Delhi.
5. An Introduction to fluid Mechanics: G.K. Batchelor; Foundation Books, New Delhi, 1994.
6. Boundary Layer Theory: H. Schichting; Mc Graw Hill Book Company, New York 1971.

M. Sc. Part I Semester IV Mathematics Practical

Course Code & Title:	LAB (M-MT541P) Based on DSC & DSE		
Teaching Hours:	12 Hours/Week	Credits:	6
Total Teaching Hours:	180 hours	Max. Marks:	150 (ESE= 100 + CIE=50)