SOBAN SINGH JEENA UNIVERSITY, ALMORA

Master of Science (Mathematics)

SYLLABUS

DEPARTMENT OF MATHEMATICS

Master of Science (Mathematics)					
Year	Semester	Course	Paper Title		Credits
FOURTH YEAR	VII	DSC Maths7	Real Analysis	Theory	4
		DSE Maths5	Topology	Theory	4
		DSE Maths6	Differential Geometry	Theory	4
		DSE Maths7	Number Theory	Theory	4
	VIII	DSC Maths8	Complex Analysis	Theory	4
		DSE Maths8	Algebra	Theory	4
		DSE Maths9	Partial Differential Equations	Theory	4
		DSE Maths10	Dynamics of Rigid Bodies	Theory	4
FIFTH YEAR	IX	DSC Maths9	Linear Algebra	Theory	4
		DSE Maths11	Measure Theory	Theory	4
		DSE Maths12	**Mathematical Statistics / Tensor Calculus	Theory	4
		DSE Maths13	**Fluid Dynamics / Discrete Mathematics	Theory	4
	X	DSC Maths10	Functional Analysis	Theory	4
		DSE Maths14	Numerical Methods	Theory	4
		DSE Maths15	**Operations Research / Relativity	Theory	4

		DSE Maths16	**Special Functions / Riemannian Geometry / Introduction to programming using MATLAB	Theory	4

** A Candidate is required to opt any one specialization out of the available specializations in fifth Year.

Abbreviations: -

DSC-Discipline Specific Course; DSE- Discipline Specific Electives; GE-Generic Electives.

Master of Science (Mathematics)

PURPOSE OF THE PROGRAM	
	The Importance of Mathematics is well known. Mathematical ideas not only help students to understand the theory of several discipline of mathematical and physical sciences but also to enhance their decision-making skills so that they can handle critical situation in a better way. The purpose of the postgraduate program in Mathematics at the university and college level is to prepare our students for all those fields where advanced mathematical skill is required for careers as well as professionals in various industries and research institutions.
PROGRAM OUTCOMES	
	PO 1. Students will have a firm foundation in the fundamentals and applications of mathematics and scientific theories. **PO 2.** Students will develop skills in problem solving, critical thinking and analytical reasoning as applied to scientific problems. **PO 3.** Students will be able to explore new directions to pursue higher studies in science subjects. **PO 4.** Students will be able to contest and qualify different competitive exams where graduation degree is one of the essential qualifications. **PO 5.** Students will be able to function as a member of an interdisciplinary problem-solving team.

PROGRAM SPECIFIC OUTCOMES (PSOS)	
	The Master of Science in Mathematics programme will enable students to join Ph. D. programme in universities and research institutes within India or abroad. The student would get research experience by doing research projects in the last semester under the supervision of faculty which will make them eligible to open up several career options in mathematics and other branches of mathematical sciences and physical sciences.

Semester-VII

Bachelor of Science (Honors)

DISCIPLINE SPECIFIC COURSE (DSC Maths7)- Real Analysis

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC Maths7: Real Analysis	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSC Maths5

Bachelor of Science (Honors)			
Programme:	*Bachelor of Science (Honors)*	Year: IV	Semester: VII Paper: DSC Maths7
Subject: Mathematics			
Course: DSC Maths7	Course Title: Real Analysis		
Course Outcomes: The core concepts of Real Analysis has been included in this course with a view that students can understand the behavior of different sets with respect to metric or distance function.			
Credits: 4			Discipline Specific Course
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	**Metric spaces**: Metric, Various examples of metric spaces, open sets, interior of a set, structure of open subsets of the real line, limit points, closed sets, closure of a set, Cauchy sequences, completeness.		12-15
Unit II	**Functions of several variables**: Concept of functions of two variables, Simultaneous and iterated limits in functions of two variables. **Partial derivatives:** Definition, Existence and continuity, Interchange of order of differentiation, Directional derivatives.		12-15

Unit III	Composite functions, Linear Continuity of function of two variables, differentiability of functions of two variables, Taylor's Theorem.	10-15
Unit IV	Linear transformation, Vector Valued functions, Differentiation of vector valued functions, inverse function theorem, implicit function theorem.	10-15

Books Recommended:

S. C. Malik and Savita Arora: Mathematical Analysis, New Age International.
G.F. Simmons: Introduction to Topology and Modern Analysis, Tata McGraw Hill.
T. M. Apostol: Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.

Further Readings:

W. Rudin: Principles of Mathematical Analysis (3rd edition), Tata Mc Graw Hill Kgakusha, International Student Edition, 1976.
Richard R. Goldberg: Methods of Real Analysis, John Wiley & Sons, 1976.

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-VII

Bachelor of Science (Honors)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths5)- Topology

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths5: Topology	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Bachelor of Science (Honors)			
Programme :	*Bachelor of Science (Honors)*	Year: IV	Semester: VII Paper: DSE Maths5
Subject: Mathematics			
Course: DSE Maths5	Course Title: Topology		
Course Outcomes: This course is useful to open up a new direction to view different shapes and other mathematical objects. This course helps to understand the concepts of topologies on a set and their properties. It will help the students for better understanding of mathematical and other disciplines of physical and natural sciences.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Topological spaces with examples, Open sets, Neighbourhood of a point, Comparable topologies, Base and sub-base of a topology, Topologies on the real number system.		10-15
Unit II	Oder topology, Product topology, Box topology, Comparison of the box and product topologies, Subspace topology, closed sets, Closure and interior of a set, Limit points, Derived sets of a set.		12-15
Unit III	Continuous functions, Open and closed functions, Homeomorphisms, Topological invariants, Rules for		10-15

	constructing continuous functions, Pasting Lemma.	
Unit IV	Connectedness, Path connected, Components, Compact spaces, Compactness of a metric space, first countable space, second countable space, Lindelof space, Separable space, $T_1, T_2, T_3, T_{3\frac{1}{2}}, T_4$, T_5, T_6, Urysohn lemma, Tietze extension theorem.	12-15

Books Recommended:

J. R. Munkres: Topology: Narosa Publishing House.
Shaum's outlines series: Tata McGraw Hill.
K. D. Joshi: Introduction to General Topology, Wiley Eastern, 1983.
M. D. Raisinghania & R. S. Aggarwal: Topology, S. Chand & Co.

Further Readings:

G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw Hill, 1963.

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-VII

Bachelor of Science (Honors)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths6)- Differential Geometry

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths6: Differential Geometry	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Bachelor of Science (Honors)			
Programme :	*Bachelor of Science (Honors)*	Year: IV	Semester: VII Paper: DSE Maths6
Subject: Mathematics			
Course: DSE Maths6	Course Title: Differential Geometry		
Course Outcomes: This course is useful to understand the concepts of geometric structures and their properties using differential calculus. It will help the students for better understanding of other subjects, especially atomic structures in chemistry and certain concepts of physics.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Curve in space, parameterized curves, regular curves, helices, arc length, reparameterization (by arc length), Tangent, principal normal, binormal, osculating plane, normal plane, rectifying plane, curvature torsion of smooth curves, Frenet- Serret formulae, Frenet approximation of space curve.		12-15
Unit II	Order of contact, osculating circle, osculating sphere, Spherical indicatrics, involutes and evolutes, Bertrand Curves, intrinsic equations of space curves, isometries of R^3, Fundamental theorem of space curves, surfaces in R^3.		10-15

Unit III	Regular Surfaces, coordinates neighborhoods, parameterized surfaces, change of parameters, level sets of smooth functions on R^3, surfaces of revolution, mean curvature, tangent vector, first and second fundamental forms, classification of points on a surface.	12-15
Unit IV	Curvature of curve on surfaces, normal curvature, Meusnier theorem, principal curvatures, geometric interpretation of principal curvatures, Euler theorem, mean curvature, line of curvature, Rodrigue's formula, umbilical points, minimal surfaces, definition and examples, Gaussian curvature.	12-15

Books Recommended:

D. Somasundaram: Differential Geometry, A First Course, Narosa Publishing House, New Delhi, 2005.

Andrew Pressley: Elementary Differential Geometry, Springer (Undergraduate Mathematics Series), 2001.

T.J.Willmore: An Introduction To Differential Geometry, Oxford University Press.

Further Readings:

J. A. Thorpe: Elementary Topics in Differential Geometry, Springer (Undergraduate Texts in Mathematics), 1979.

B.O.Niell: Elementary Differential Geometry, Academic Press.

Do Carmo : Curves and surfaces,

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-VII

Bachelor of Science (Honors)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths7)- Number Theory

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths7: Number Theory	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Bachelor of Science (Honors)			
Programme :	*Bachelor of Science (Honors)*	Year: IV	Semester: VII Paper: DSE Maths7
Subject: Mathematics			
Course: DSE Maths7	Course Title: Number Theory		
Course Outcomes: The core concepts of numbers have been included in this course with a view that students can understand the behavior of prime numbers and natural numbers in a critical way.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Divisibility theory, Prime Numbers, Unique factorization theorem, Diophantine equation, Congruence, Chinese remainder theorem.		8-10
Unit II	Fermet's theorem, Wilson's theorem, Euler's theorem, Pseudoprimes, Continued fractions.		10-12
Unit III	The arithmetic functions: d(n), σ(n), μ(n) and $\varphi(n)$ including elementary result on their order and average order.		10-12
Unit IV	Farey series, Irrational numbers, Residues, Quadratic Reciprocity Law, Primitive roots, Non-linear Diophantine equation $X^2 + Y^2 = Z^2, X^4 + Y^4 = Z^4,\ aX^2 + bY^2 + cZ^2 = 0.$		10-12

Books Recommended:

G. H. Hardy and E. M. Wright: Introduction to the theory of numbers, Oxford University Press, 4th Edition.
D. M. Burton: Elementary Number Theory, 6th Edition, Tata McGraw Hill.
Thomas Koshy: Elementary Number Theory with Applications, Academic Press, 2nd Edition.
Kenneth H. Rosen: Elementary Number Theory and its Applications, Addison-Wesley Publishing Company, 1986.

Further Readings:

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-VIII

Bachelor of Science (Honors)

DISCIPLINE SPECIFIC COURSE (DSC Maths8)- Complex Analysis

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC Maths8: Complex Analysis	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSC Maths5

Bachelor of Science (Honors)			
Programme :	*Bachelor of Science (Honors)*	Year: IV	Semester: VIII Paper: DSC Maths8
Subject: Mathematics			
Course: DSC Maths8	Course Title: Complex Analysis		
Course Outcomes: Upon successful completion of this course, the students will be able to understand the theory used to solve the mathematical problems. It also helps to enhance the critical thinking of the students.			
Credits: 4			Discipline Specific Course
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Conformal mappings, Power series representation of analytic functions, Analytic functions as mappings, Riemann sphere, Linear transformations, Mobius transformation, Cross ratios, Mobius transformation on circles.		12-15
Unit II	Complex integration, Cauchy theorem, Cauchy integral formula, Derivative of an analytic function, Higher order derivatives, Morera's theorem, Cauchy inequality and Liouville's theorem.		12-15
Unit III	Counting zeros, The open mapping theorem, Maximum modulus principle, Schwarz lemma, The fundamental		12-15

	theorem of algebra.	
Unit IV	Entire functions, Hadmard's three circle theorem, Jensen's formula, Meromorphic functions, Argument principle, Rouche's theorem.	12-15

Books Recommended:

J. B. Conway*: Functions of One Complex Variable*, Narosa Publishing House, 1980.
R. V. Churchil and J. W. Brown and R. F. Verhey: *Complex Variables and Applications,* McGraw Hill Edition, 1976.

Further Readings:

L. V. Ahlfors: *Complex Analysis*, McGraw Hill Edition, 1977.
E. T. Copson: *Complex Variables*, Oxford University Press.
Richard R. Goldberg: *Methods of Real Analysis*, John Wiley & Sons, 1976.
D. Sarason: *Complex Function Theory*, Hindustan Book Agency, Delhi, 1994.
James R. Munkres: *Analysis on Manifolds*, Addison-Wesley Publishing Company, Advanced Book Program, Redwood City, CA, 1991.
H. L. Royden: *Real Analysis,* Macmillan Publishing Company, New York, 1988.
G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw Hill Edition, 2011.
Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-VIII

Bachelor of Science (Honors)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths8)- Algebra

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths8: Algebra	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Bachelor of Science (Honors)			
Programme :	*Bachelor of Science (Honors)*	Year: IV	Semester: VIII Paper: DSE Maths8
Subject: Mathematics			
Course: DSE Maths8	Course Title: Algebra		
Course Outcomes: This course will help students to understand the concept of algebraic structures especially groups and rings.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Normal and subnormal series, Composition series, Jordan Holder theorem, Chain conditions.		12-15
Unit II	Commutators, Solvable groups, Solvability of subgroups and factor groups. Nilpotent groups and their equivalent characterizations.		13-15
Unit III	Rings, Ideals, Prime and maximal ideals, Quotient rings. Factorization theory in commutative domains. Prime and irreducible elements, Euclidean Domains. Principal Ideal Domain. Divisor chain condition. Unique Factorization Domains, Polynomial rings over domains. Eisenstein's irreducibility criterion. Unique factorization in polynomial rings over UFDs.		15-18

Unit IV	Fields, finite fields, field extensions, Algebraic extension, Splitting fields, Normal extension, Galois extensions.	10-15

Books Recommended:

J. Gallian: Abstract Algebra, Narosa Publication.
Ramji Lal: Fundamentals in Abstract Algebra, Chakra Prakashan, Allahabad, 1985.
I. N. Herstein: Topics in Algebra, Wiley Eastern Ltd., N.D., 1975.

Further Readings:

M. Artin: Algebra, Prentice Hall of India.
N. Jacobson: Basic Algebra, Vol. I, Hindustan Publishing Co., New Delhi.
D. S. Dummit and R. M. Foote: Abstract Algebra, John Wiley, N. Y.

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-VIII

Bachelor of Science (Honors)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths9)- Partial Differential Equations

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths9: Partial Differential Equations	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Bachelor of Science (Honors)			
Programme:	*Bachelor of Science (Honors)*	Year: IV	Semester: VIII Paper: DSE Maths9
Subject: Mathematics			
Course: DSE Maths9	Course Title: Partial Differential Equations		
Course Outcomes: To solve any real-world problem mathematically, differential equations are widely used. This course will help students to deal with such problems and use differential equations to solve them.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs., General theory of homogeneous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function.		10-15
Unit II	Formation of PDEs, First order PDEs, Complete, general and singular integrals, Lagrange's or quasi-linear equations, Integral surfaces through a given curve. Orthogonal surfaces to a given system of surfaces,		12-15

	Characteristic curves.	
Unit III	Pfaffian differential equations, Compatible systems, Char pit's method, Jacobi's Method. Cauchy problem for first order PDEs.	12-15
Unit IV	Linear equations with constant coefficients, Reduction to canonical forms, Classification of second order PDEs, General solution of higher order PDEs with constant coefficients.	10-15

Books Recommended:

G. F. Simmons: Differential Equations with Application and Historical Notes, McGraw Hill Edition, 2002.
Shepley L. Ross: Differential Equations, John Wiley & Sons, 1984.
M. D. Raisinghania: Ordinary & Partial Differential Equation, S. Chand & Co. Ltd, 2017.
B. Rai, D. P. Choudhary and H. J. Freedman: A Course of Ordinary Differential Equations, Narosa, 2002.

Further Readings:

Earl A. Coddington and Norman Levinson: Theory of Ordinary Differential Equations, McGraw-Hill Edition, 1998.
Ravi P. Agarwal and Donal O'Regan: Ordinary and Partial Differential Equations, Springer, 2009.
Martin Braun: Differential Equations and Their Applications, Sringer, 1993.
Erwin Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons, 2011.
Ian N. Snedden: Elements of Partial Differential Equations, Dover Publication, 2013.
Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-VIII

Bachelor of Science (Honors)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths10)- Dynamics of Rigid Bodies

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths10: Dynamics of Rigid Bodies	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Bachelor of Science (Honors)			
Programme :	*Bachelor of Science (Honors)*	Year: IV	Semester: VIII Paper: DSE Maths10
Subject: Mathematics			
Course: DSE Maths10	Course Title: Dynamics of Rigid Bodies		
Course Outcomes: This course is useful to understand the concepts of motion of rigid bodies. It will help the students for better understanding of the other subjects, especially in engineering and certain concepts of physics.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	D'Alembert's principle, Motion about a fixed axis (Finite and Impulsive forces).		10-15
Unit II	Motion in two dimensions under Finite and Impulsive forces, Principle of conservation of momentum and energy.		12-15
Unit III	Generalized coordinates, constraints, Lagrange's equations in generalized co-ordinates.		10-15
Unit IV	Hamilton's principle, Hamilton's equations, principle of least action, Euler's geometrical and dynamical equations.		12-15

Books Recommended:

Bhu Dev Sharma: Dynamics of Rigid Bodies, Kedarnath Ramnath Sons, 1984.
M. Ray & Harswarup Sharma: A text book of Dynamics of Rigid Body, Students' Friends &Co., Agra-2, 1971.
H. Goldstein: Classical Mechanics, Narosa, 1990.

Further Readings:

S. L. Loney: Dynamics of rigid bodies.
A. S. Ramsey: Dynamics – Part II.

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-IX

Master of Science (Mathematics)

DISCIPLINE SPECIFIC COURSE (DSC Maths9)- Linear Algebra

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC Maths9: Linear Algebra	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSC Maths5

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: IX Paper: DSC Maths9
Subject: Mathematics			
Course: DSC Maths9	Course Title: Linear Algebra		
Course Outcomes: The core concepts of Linear Algebra have been included in this course with a view that students can understand the behavior of mathematical entities called vector spaces.			
Credits: 4			Discipline Specific Course
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	A brief review of vector space and linear transformation, Inner product space, Cauchy-Schwartz inequality Orthogonality, Best approximations, Projections, Gram-Schmidt orthogonalization.		12-15
Unit II	Adjoint of a linear transformation, Self-adjoint transformations, Unitary operators, Orthogonal projections.		12-15
Unit III	Normal operators: Definition and properties, Spectral theory and related properties of normal operators.		10-15
Unit IV	Bilinear form, Quadratic forms, Symmetric bilinear form, Skew- Symmetric bilinear form, Group preserving bilinear form.		10-15

Books Recommended:

K. Hoffman and R. Kunze: *Linear Algebra*, Prentice Hall of India, 1972.
K. B. Dutta: *Matrix and Linear Algebra*, Prentice Hall of India, 2004.
Seymour Lipschutz and Marc L. Lipson*: Linear Algebra,* Schaum's Outline Series, McGraw Hill Edition, 2017.
S. H. Friedberg, A. J. Insel and L. E. Spence: *Linear Algebra,* Pearson Education, 2015.

Further Readings:

G. Hadley: *Linear Algebra,* Narosa Publishing House, 2002.
H. Helson: *Linear Algebra*, Hindustan Book Agency, New Delhi, 1994.
Gilbert Strang: *Linear Algebra and its Applications,* Cengage Learning India, 2005.

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-IX

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths11)- Measure Theory

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths11: Measure Theory	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: IX Paper: DSE Maths11
Subject: Mathematics			
Course: DSE Maths11	Course Title: Measure Theory		
Course Outcomes: The core concepts of measure and integration have been included in this course with a view that students can understand the measure of sets and summation over the sets.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Countable sets, uncountable sets, relation between the cardinality of a nonempty set and the cardinality of its power set; Boolean ring, σ-ring, Boolean algebra and σ-algebra of sets, Set function.		12-15
Unit II	Introduction, Outer measure, Measurable sets and Lebesgue measure, Example of non-measurable sets, Measurable functions.		10-15
Unit III	The Riemann integral, The Lebesgue integral of a bounded function over a set of finite measure, The integral of nonnegative functions, Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem, The		12-15

	general Lebesgue integral, Convergence in measure.	
Unit IV	Differentiation of monotone functions, Functions of bounded variation, Differentiation of an integral, Absolute continuity, convex functions.	10-15

Books Recommended:

P. K. Jain: Measure Theory, New Age International.
P. R. Halmons: Measure Theory, Grand Text Mathematics, 14 Springer, 1994.
I. K. Rana: An Introduction to Measure and Integration, (Second Edition), Narosa Publishing House, New Delhi, 2005.

Further Readings:

E. T. Copson: Complex Variables, Oxford University Press. K.R. Parthasarathy: Introduction to Probability and Measure, TRIM 33, Hindustan Book Agency, New Delhi, 2005.
E. Hewit and K. Stromberg: Real and Abstract Analysis, Springer, 1975.
H. L. Royden: Real Analysis, Macmillan Publishing Company, New York, 1988.

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-IX

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths12A)- Mathematical Statistics

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths12A: Mathematical Statistics	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: IX Paper: DSE Maths12A
Subject: Mathematics			
Course: DSE Maths12A	Course Title: Mathematical Statistics		
Course Outcomes: Upon completion of this course, students will be enabled to apply statistical methods in addition to various mathematical methods.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Descriptive Statistics: Measures of central tendency, dispersion skewness and kurtosis Elements of probability: Sample space, discrete probability, independent events, Baye's theorem, random variables and distribution functions (univariate, bivariate, and generalization to multivariate).		10-15
Unit II	Mathematical expectation and moments: Moment generating function, Characteristic function and cumulants. Probabilistic inequalities. Modes of convergence: weak and strong laws of large numbers. Central limit theorem (i.i.d. case). Markov chains with		12-15

	finite and countable state space, Poisson and birth- and-death processes.	
Unit III	Some standard discrete and continuous univariate distributions (Binomial, Poisson, Normal, Gamma and Beta), Distribution of order statistics and range.	10-15
Unit IV	Correlation, Rank correlation. Regression lines. Multiple and partial correlation of three variables only, Data reduction techniques: Principal component analysis, discriminant analysis, cluster analysis, canonical correlation.	12-15

Books Recommended:

M.G.Kendall: Advanced theory of statistics Vol. I &II, Charle's Griffiin & Co.
R. Hogg and A Craig: Introduction to Mathematical Statistics, Mac Millan & Co.
C.E. Weatherbun: A first course in Mathematical Statistics, The English Language Book Society and Cambridge University Press, 1961.
S.C. Gupta & V.K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand & Co

Further Readings:

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-IX

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths12B)- Tensor Calculus

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths12B: Tensor Calculus	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year:V	Semester: IX Paper: DSE Maths12B
Subject: Mathematics			
Course: DSE Maths12B	Course Title: Tensor Calculus		
Course Outcomes: The core concepts of tensors have been included in this course with a view that students will be benefitted by the algebra of tensors. This helps students to understand various courses like Einstein's theory of Relativity, Image processing etc.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	n-dimensional real vector space, transformation of coordinates, invariants, contravariant and covariant vectors, tensors of order two: contravariant tensors, covariant tensors and mixed tensors, higher order tensors, operations on tensors: addition, subtraction, multiplication, contraction and inner product.		10-15
Unit II	Symmetric and skew symmetric tensors, quotient law of tensors, relative tensors.		10-15
Unit III	metric tensor, length of a curve, magnitude of vector, angle between two vectors, associated tensors, conjugate symmetric tensors,		12-15

Unit IV	Christoffel symbols, transformation rule and group property, covariant derivative, intrinsic derivative, Gradient, divergence and curl.	13-15

Books Recommended:

N. Islam: Tensors and their applications, New Age International Publishers, 2006.
C.E. Weatherburn: Riemannian Geometry and Tensor Calculus.
B. Spain: Tensor Calculus.

Further Readings:

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-IX

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths13A)- Fluid Dynamics

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths13A: Fluid Dynamics	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: IX Paper: DSE Maths13A
Subject: Mathematics			
Course: DSE Maths13A	Course Title: Fluid Dynamics		
Course Outcomes: This course will enable students to understand how the motion of fluids is studied using mathematical tools.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Lagrangian and Eulerian methods, Equation of continuity, Boundary surface, Stream lines, Velocity potential, Euler's equation of motions, Bernoulli's theorem, Helmholtz equations, Cauchy's integral, Equation of action under impulsive forces, Principal of energy.		10-15
Unit II	Motion in two dimensions, Velocity potential and current functions, Sources and sinks, Doublet and images, Circle theorem, Motion of circular and elliptic cylinder in two dimensions, Joukowski transformation, Motion in three dimensions, three dimensional sources, Sinks and doublets, Image of source in front of sphere, Motion of spheres, Stroke's stream function.		12-15

Unit III	General theory of irrotational motion, Permanence of irrotational motion circulation, Stroke's theorem, Kelvin's circulation theorem, Green's theorem, Kelvin's minimum energy theorem, Conformal Representation, Kutta and Joukowski transformation, Theorems of Schwartz Christoffel.	12-15
Unit IV	Vortex motion: Rectilinear vortices, rectilinear vortex with a circular section, An infinite row of parallel rectilinear vortices, Karman stream, Use of conformal transformation, Vortex pairs.	10-15

Books Recommended:

A. S. Ramsey: A Treatise on Hydrodynamics.
W. H. Besant and A. S. Ramsey: A Treatise on Hydrodynamics, CBS Publisher and Distributors, Delhi, 1988.
M. D. Raisinghania: Fluid Dynamics, S. Chand, 1939

Further Readings:

F. Chorlton: A Text Book of Fluid Dynamics, CBC, 1985.
S.W. Yuan: Foundations of Fluid Dynamics, Prentice-Hall of India,1988.

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-IX

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths13B)- Discrete Mathematics

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths13B: Discrete Mathematics	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: IX Paper: DSE Maths13B
Subject: Mathematics			
Course: DSE Maths13B	Course Title: Discrete Mathematics		
Course Outcomes: This course will enable students to understand various concepts which are useful for higher study in other disciplines of mathematical sciences like computer science, data science etc.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Symbolic logic and truth, Principle of mathematical induction (direct and contradiction method), partially ordered sets, Lattices: Lattices as partially ordered sets, Their Properties, Lattices and algebraic systems. Principle of duality, Sub lattices, Complete, Complemented and Distributive lattices.		12-15
Unit II	Boolean algebra, Boolean functions, Boolean expressions, Applications to switching circuits.		10-15
Unit III	Elements of graph theory: Basic terminology, Paths and circuits, Eulerian and Hamiltonian graphs, Euler's theorem, planar graphs, Directed graphs.		12-15

Unit IV	Trees: Rooted trees, path lengths, spanning trees, minimum spanning trees, Search algorithm like D.F.S. and B.F.S..	12-15

Books Recommended:

C. L. Liu: Elements of discrete mathematics, Tata McGraw Hill Education, 2008.
Ram Babu: Disrete Mathematics, Pearson Edition India, 2011.
Lipschutz: Disrete Mathematics, Tata McGraw Hill, 2011.
K. H. Rosen; Discrete Mathematics and its Applications, Mc-Graw Hill, 2011.
J. Matoušek and J. Nešetřil; Invitation to Discrete Mathematics, Oxford University Press, 2008.

Further Readings:

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-X

Master of Science (Mathematics)

DISCIPLINE SPECIFIC COURSE (DSC Maths10)- Functional Analysis

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC Maths10: Functional Analysis	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSC Maths5

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: X Paper: DSC Maths10
Subject: Mathematics			
Course: DSC Maths10	Course Title: Functional Analysis		
Course Outcomes: The core concepts of Functional Analysis have been included in this course with a view that students can understand the behavior of functions on vector spaces.			
Credits: 4			Discipline Specific Course
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Convergence of sequences in metric space, Normed spaces, l_p space, Holder's and Minkowski's inequality, Banach space, Properties of Normed spaces, Finite dimensional normed spaces and subspaces, Quotient spaces, Compactness and finite dimension, linear operators, Bounded and continuous linear operators; Linear functional; linear operators and functional on finite dimensional spaces, Normed spaces of operators, Dual space.		12-15
Unit II	Inner product space; Hilbert space; Properties of inner product spaces, Orthogonal complements and direct sums,		12-15

	Orthonormal sets and sequences; Hilbert adjoint operators, Self-Adjoint, Unitary and normal operators, orthogonal projections, Projection theorem.	
Unit III	Fundamental Theorems of Normed and Banach Space: Zorn's Lemma, Hahn Banach Theorem, Hahn Banach Theorem for complex vector spaces and normed spaces, Applications to bounded linear functionals on C[a, b], Adjoint operators, Uniform boundedness theorem, strong and weak convergence, convergence of sequences of operators and functional, Applications of summability of sequences, Open mapping theorem and closed graph theorem.	10-15
Unit IV	Banach contraction principle, Applications of Banach's theorem to linear, differential and integral equations, Approximation in Normed spaces, Uniqueness, strict convexity, Uniform approximation, approximation in Hilbert spaces.	12-15

Books Recommended:

Erwin Kreyszig: Introductory Functional Analysis, Wiley India edition.
G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw Hill, 1963.
A. E. Taylor: Introduction to Functional Analysis, John Wiley, 1958.
R. E. Edwards: Functional Analysis, Holt Rinehart and Winston, 1965

Further Readings:

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-X

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths14)- Numerical Methods

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths14: Numerical Methods	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: X Paper: DSE Maths14
Subject: Mathematics			
Course: DSE Maths14	Course Title: Numerical Methods		
Course Outcomes: This course will help students to extend their understanding of mathematical tools and they will be able to use new methods of problem solving.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	**Errors in numerical Calculations:** Absolute, Relative, Percentage errors, General Error, Error in series approximation. **Solutions of Algebraic and Transcendental Equations:** Bisection method, false position method, Newton-Raphson and generalized Newton's Method, Graffe's root squaring method, Lin Bairstow's method, Picard's iteration method, convergence and error estimates of iterative methods.		10-15
Unit II	**Linear systems of equations:** Consistency of Linear System of equations, **solutions of linear systems by direct methods**: Gaussian elimination and computation of inverse of a matrix, Method of Factorization, Solutions of		12-15

	Tridiagonal systems and ill conditioned linear systems. **Solutions of linear systems by iterative methods**: Jacobi method, Gauss- Siedel method.	
Unit III	**Interpolation and curve fitting:** Errors in Polynomial interpolation, Finite differences, Differences of a polynomial, Newton's forward and backward interpolation, Central differences, Gauss, Stirling, Bessel's and Everett's Formulae, Practical interpolation and interpolation with unevenly spaced points, Lagrange's Interpolation formula, Divided difference and Newton's General interpolation formula, least square curve fitting procedure.	10-15
Unit IV	**Numerical differentiation and integration:** Numerical differentiation, cubic Spline method, Maximum and minimum values of tabulated function, Newton-Cotes Integration formula, Numerical integration by Trapezoidal rule, Simpson's 1/3, Simpson's 3/8, Weddle's rule and Romberg Integration. Numerical solution of ODE by Picard's, Euler's, Modified Euler's and Runge-Kutta methods.	12-15

Books Recommended:

S. S. Sastry: Introductory Methods Numerical Analysis, Prentice- Hall of India.
C.F. Gerald and P. O. Wheatley: Applied Numerical Analysis, Addison- Wesley, 1998.Further Readings:
Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-X

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths15A)- Operations Research

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths15A: Operations Research	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: X Paper: DSE Maths15A
Subject: Mathematics			
Course: DSE Maths15A	Course Title: Operations Research		
Course Outcomes: This course will enable students to understand various methods for the solution of optimization problem.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	**Basics of OR and LPP:** Development of OR, Definition, characteristics, scope, objectives and limitations of OR, Formulation of LPP, Graphical Method to solve LPP, General LPP, Canonical and Standard forms, Properties of Solutions and Theory of Simplex method, Big M-Method and Two-phase simplex method, Degeneracy in LPP, Duality in LPP, Duality and simplex method, Dual simplex method, Revised simplex method.		12-15
Unit II	**Sensitivity Analysis:** Changes in Objective Function Coefficient, Changes in constants, Changes in coefficients of decision variables in constraints, Structural changes.		10-15

Unit III	**Integer Programming and Game Theory:** Branch and Bound (B&B) algorithm, Cutting-Plane algorithm, Optimal solution of two-person zero-sum games, Solution of mixed strategy games.	12-15
Unit IV	**Transportation Models and Assignment Models:** LPP Formulation of TP, Transportation Table, finding initial basic feasible solution, Vogel approximation method (VAM), Travelling salesman problem, Test of optimality, Degeneracy, MODI method, Stepping Stone method, Solutions of Assignment problems, Hungerian method, Duality in assignment problem.	10-15

Books Recommended:

H. A. Taha: Operations Research, An Introduction, Pearson.
Kanti Swarup, P K Gupta, Manmohan: Operations Research, Sultan Chand & Sons, New Delhi.
S.S. Rao: Optimization Theory and Applications Wiley Eastern.

Further Readings:

F. S. Hiller and G. J. Leiberman: Introduction to Operation Research (6th Edition), McGraw-Hill International Edition, 1995.

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-X

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths15B)- Relativity

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths15B: Relativity	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: X Paper: DSE Maths15B
Subject: Mathematics			
Course: DSE Maths15B	Course Title: Relativity		
Course Outcomes: The core concepts of Relativity have been included in this course with a view that students can understand the behavior of solar system and space in a critical way.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Special Relativity: Inertial Frames of reference, Michelson-Morley experiment, Doppler effect, Stellar aberration, Simultaneity, Postulates of special relativity, Lorentz transformation, Length contraction, Time dilation, Clock paradox, Addition of velocities and accelerations, Four-dimensional space time, Light cone, Mass variation, Velocity four vector, Momentum and force, Mass-Energy relationship.		10-15
Unit II	General Relativity: Geodesics, Geodesic coordinates, Curvature tensor and its algebraic properties, Bianchi's identities, Contracted curvature tensor, Conditions for a flat space time, Displacement of space –time, Killing		12-15

	equations, Groups of motion, Space –time of constant curvature.	
Unit III	Principal of covariance, non-inertial frames of reference, Principal of equivalence, Weak field approximation of geodesic equations, Law of gravitation in empty space-time, Canonical coordinates, Schwarzschild solutions.	10-15
Unit IV	Experimental tests of general relativity, Schwarzschild metric in isotropic coordinates, Brikhoff's theorem, Law of gravitation in non-empty space time.	10-15

Books Recommended:

D.F. Lawden: An Introduction to tensor calculus and relativity,
J.V. Narlikar: General relativity and cosmology.
R.H. Good: Basic concept of relativity, 1978.

Further Readings:

A.S. Eddington: Mathematical theory of relativity, 1981.

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-X

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths16A)- Special Functions

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths16A: Special Functions	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: X Paper: DSE Maths16A
Subject: Mathematics			
Course: DSE Maths16A	Course Title: Special Functions		
Course Outcomes: This course will extend the knowledge of functions to the students by adding the class of functions defined using integrals.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	Preliminaries, Gamma function and related functions, Gauss multiplication theorem, the hypergeometric differential equation, Gauss hypergeometric function.		10-15
Unit II	Integral representation of hypergeometric function, Evaluation of hypergeometric function, the confluent hypergeometric differential equation, Confluent hypergeometric function.		12-15
Unit III	Bessel's equation, solution of Bessel's equation, Bessel's functions Jn(x), Recurrence Formulae, Equations reducible to Bessel's equation, orthogonality of Bessel's Functions, A generating function for Jn(x), Basic properties.		12-15

Unit IV	Legendre's equation, Legendre's polynomial Pn(x), Legendre's function of the second kind Qn(x), General solution of Legendre's equation, Rodrigue's formula, Legendre polynomials, A generating function of Legendre's polynomial, Orthogonality of Legendre polynomial.	12-15

Books Recommended:

E.D. Rainville: Special functions.
Nirvikar Saran: Special Functions.
W.W. Bell: Special Function for Scientists and Engineers, Dever publications, 2002,
U.P. Singh: Special Function & Their Application, WISDOM PRESS, 2012.

Further Readings:

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-X

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths16B)- Riemannian Geometry

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths16B: Riemannian Geometry	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: X Paper: DSE Maths16B
Subject: Mathematics			
Course: DSE Maths16B	Course Title: Riemannian Geometry		
Course Outcomes: This course is useful to view geometry of the space where our Euclidean geometry is not applicable. It will help the students for better understanding of other disciplines of physical and natural sciences.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	N-dimensional real vector space and its dual space, multilinear functions on vector spaces, tensor product, contravariant and covariant vectors, second order tensors, tensors of type (r,s). Algebraic Operations on tensors, Symmetric and skew symmetric properties, inner product of vectors, Euclidean vector space.		12-15
Unit II	Differentiable manifold, Lie-bracket, Tangent space, Connections, Covariant derivatives, Curvature tensor, Parallelism, Lie derivative, Exterior derivative, Cartan's structural equations.		12-15
Unit III	Riemannian geometry: Riemannian metric, Christoffel		13-15

	symbols, Curvature tensor with respect to Christoffel symbols, Differential operators, Geodesics, Geodesic coordinates, Riemannian curvature, Conformal curvature tensor, Frenet's formulae.	
Unit IV	Sub-manifolds and Hypersurfaces: Normals, Gauss's formulae, Weingarten equations, Coordinate viewpoint, Lines of curvature, Generalized Gauss and Mainardi-Codazzi equations.	12-15

Books Recommended:

R.S. Mishra: A Course in tensors with applications to Riemannian Geometry, Pothishala Pvt. Ltd., Allahabad, 1965.

R. L. Bishop and S. I. Goldberg: Tensor Analysis on Manifolds, Dover Publications, New York.

S. S. Chern: Differentiable Manifolds, University of Chicago, Chicago.

Further Readings:

K. Yano: The theory of Lie derivatives and its applications, North-Holland Publishing Company, Amsterdam, 1957.

Matthew S. Smith: Principal and Application of Tensor Analysis, W. Sons (Indianapolis) 1963.

H.S. Shukla, Prasad & Dhruwa Narain Dubey: Differential Geometry of Manifolds, Vandana Prakashan, Mohanlalpur, Gorakhpur.

Digital Platform: NPTEL/SWAYAM/MOOCs.

Semester-X

Master of Science (Mathematics)

DISCIPLINE SPECIFIC ELECTIVE (DSE Maths16C)-Introduction to programming using MATLAB

No. of Hours: 50-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE Maths16C: Introduction to programming using MATLAB	4	3	2	0	Passed diploma in Science with Mathematics	Completed DSE Maths3

Master of Science (Mathematics)			
Programme :	*Master of Science (Mathematics)*	Year: V	Semester: X Paper: DSE Maths16C
Subject: Mathematics			
Course: DSE Maths16C	Course Title: Introduction to programming using MATLAB		
Course Outcomes: This course is useful to do mathematical computations using computer. It will help the students for better understanding of mathematical concepts.			
Credits: 4			Discipline Specific Elective
Max. Marks: As per Univ. rules			Min. Passing Marks: As per Univ. rules
Unit	Content		Number of Hours
Unit I	MATLAB Basics: Introduction to MATLAB, Input and Output, Arithmetic, Algebra; Symbolic Expressions, Variables and Assignments, Solving Equations, Vectors and Matrices, Functions: Built-in Functions, User-Defined Functions.		12-15
Unit II	Data Classes: String Manipulation, Symbolic and Floating-Point Numbers, Functions and Expressions, Complex Arithmetic, Matrices, Solving Linear Systems, Calculating Eigenvalues and Eigenvectors, Doing Calculus with MATLAB (Differentiation, Integration, Limits, Sums		12-15

	and Products, Taylor Series etc)	
Unit III	MATLAB Graphics: Two-Dimensional Plots, Parametric Plots, Contour Plots and Implicit Plots, Field Plots, Three-Dimensional Plots, Curves in Three-Dimensional Space, Surfaces in Three-Dimensional Space, Special Effects, Animations	13-15
Unit IV	MATLAB Programming: Branching with if, Logical Expressions, Branching with switch, Loops, User defined functions, M-Files	12-15
Note: Practical assignments using statistical and numerical techniques.		

Books Recommended:

Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg: A Guide to MATLAB for Beginners and Experienced Users, Cambridge University Press, 2001

Stormy Attaway: MAT LAB A Practical Introduction to Programming and Problem Solving, Elsevier, 2017

Digital Platform: NPTEL/SWAYAM/MOOCs.

Pattern of Examination Theory Papers

1. Theory

Each theory paper shall consist of two sections A and B.
Section A (Short answers type with reasoning): 45 marks, eight questions of nine marks each, any five have to be attempted.
Section B (Long answers type): 30 marks, two questions of fifteen marks each, and both questions are compulsory with internal choice.

2. Internal assessment

For each theory paper internal assessment shall be conducted periodically (in the form of class tests and/or assignments/ group discussion/ oral presentation/ overall performance) during the semester period. Total marks allotted to internal assessment shall be 25. The evaluated answer sheets/assignments have to be retained by the Professor In-Charge for the period of six months and can be shown to the students if students want to see the evaluated answer sheets. The marks obtained by the students shall be submitted to the Head of concerned department/ the Principal of the College for uploading onto the University examination portal.