MANIPAL UNIVERSITY
JAIPUR

Department of Mathematics and Statistics

School of Physical and Biological Sciences
Faculty of Science, Technology and Architecture

B.Sc. (Hons.) Mathematics
(2025 – 2028)

Year	FIRST SEMESTER						SECOND SEMESTER					
	Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
I	MAS1110	Fundamental of Calculus	3	1	0	4	MAS1211	Group Theory	3	1	0	4
	CHY1106	States of Matter	3	1	0	4	PHY1204	Electricity and Magnetism	3	1	0	4
	PHY1103	Oscillations and Wave Optics	3	1	0	4	PHY1232	Electricity and Magnetism Lab	0	0	4	2
	CHY1134	Chemistry Lab 1	0	0	4	2	CHY1205	Stereochemistry and Reaction Mechanisms	3	1	0	4
	PHY1132	Wave and Optics Lab	0	0	4	2	MAS1212	Ordinary Differential Equations	3	1	0	4
	LLC1110	Communicative English	2	0	0	2	CAP1203	Principles of Programming Languages	2	1	0	3
	CAP1180	Fundamentals of Computer	1	1	2	3	CHY1234	Chemistry Lab 2	0	0	4	2
	CHY1003	Environmental Science	3	0	0	3	MAS1213	Indian Knowledge System	1	0	0	1
			15	**4**	**10**	**24**			**15**	**5**	**8**	**24**
	Total Contact Hours (L + T + P)		**29**				**Total Contact Hours (L + T + P)**		**28**			
II	**THIRD SEMESTER**						**FOURTH SEMESTER**					
	MAS2112	Real Analysis	3	1	0	4	MAS2211	Multivariate Calculus	3	1	0	4
	MAS2113	Ring & Field Theory	3	1	0	4	MAS2212	PDE & System of ODE	3	1	0	4
	MAS2114	Linear Programming Problems	3	1	0	4	MAS2213	Linear Algebra	3	1	0	4
	MAS2126	Basics of Number Theory	2	0	0	2	MAS2218	Vector Calculus & Metric Space	3	1	0	4
	MAS2127	Introduction to Higher Trigonometry	2	0	0	2	MAS2226	Analytical Geometry of Three Dimensions	3	1	0	4
	******	GE – III (A)	2	1	0	3	******	DSE – I	3	1	0	4
	******	GE – III (A) Lab	0	0	2	1	******	Open Elective	2	1	0	3
	******	GE – III (B)	2	1	0	3						
	******	GE – III (B) Lab	0	0	2	1						
			17	**5**	**4**	**24**			**20**	**7**	**0**	**27**

	Total Contact Hours (L + T + P)		**26**				**Total Contact Hours (L + T + P) + OE**		**24+3=27**			
III	**FIFTH SEMESTER**						**SIXTH SEMESTER**					
	MAS3101	Numerical Analysis	2	1	0	3	MAS3201	Complex Analysis	3	1	0	4
	MAS3103	Dynamics	3	1	0	4	MAS3202	Riemann Integration & Series of Functions	3	1	0	4
	MAS3104	Integral Transforms	3	1	0	4	MAS3204	Statics	3	1	0	4
	MAS3130	Lab on Numerical Analysis	0	0	2	1	******	DSE – III (A)	2	1	0	3
	MAS3170	DSE – II - Project	0	0	0	6	******	DSE – III (B)	2	1	0	3
	******	DSE – II (A)	2	1	0	3	******	GE – IV	2	1	0	3
	******	DSE – II (B)	2	1	0	3	******	GE – IV Lab	0	0	2	1
							******	Open Elective	2	1	0	3
			12	**5**	**2**	**24**			**17**	**7**	**2**	**25**
	Total Contact Hours (L + T + P)		**19**				**Total Contact Hours (L + T + P) + OE**		**23 +3 = 26**			

Discipline Specific Electives (DSE)

DSE – I

1. MAS2240 Statistical Inference[#]
2. MAS2230 Lab on Statistical Inference[#]
3. MAS2241 Inventory Theory and Dynamic Programming
4. MAS2242 Information Theory
5. MAS2243 Mathematical Finance

DSE – II (A)

1. MAS3140 Basic Econometrics
2. MAS3141 Modeling & Simulation

DSE – II (B)

1. MAS3142 Reliability Modeling & Analysis
2. MAS3143 Portfolio Optimization
3. MAS3144 Operations Research

DSE – III (A)

1. MAS3241 Multivariate Analysis
2. MAS3242 Numerical Methods of Ordinary and Partial Differential Equations

DSE – III (B)

1. MAS3243 Mechanics
2. MAS3245 Introduction to Graph Theory

Skill Enhancement Courses (SEC)

1. CAP1180 Fundamentals of Computer
2. CAP1133 Fundamentals of Computer Lab
3. MAS2115 Data Analysis using R
4. MAS2116 Introduction to C Language

Generic Electives (GE)

GE – I & Lab

1. MAS1140 Descriptive Statistics
2. MAS1130 Lab on Descriptive Statistics
3. CHY1160 General Chemistry-I
4. CHY1138 Organic Chemistry Laboratory
5. PHY1160 Mechanics and STR
6. PHY1136 General Physics Lab-I

GE – II (A) & Lab

1. MAS1240 Probability Theory & Random Variables
2. MAS1230 Lab on Probability & Random Variables
3. CHY1260 General Chemistry-II
4. CHY1238 Inorganic Chemistry Laboratory
5. PHY1261 Electromagnetism

GE – II (B) & Lab

1. MAS1241 Applied Statistics
2. MAS1231 Lab on Applied Statistics
3. CHY1261 General Chemistry-III
4. CHY1239 Physical Chemistry Laboratory
5. PHY1260 Oscillation and Wave Optics
6. PHY1236 Optics Lab

GE – III (A) & Lab

1. MAS2140 Distribution Theory
2. MAS2130 Lab on Distribution Theory
3. CHY2160 Analytical Chemistry
4. CHY2138 Analytical Chemistry Laboratory
5. PHY2161 Heat and Thermodynamics

GE – III (B) & Lab

1. MAS2141 Sampling Theory
2. MAS2131 Lab on Sampling Theory
3. CHY2161 Structure of Materials
4. CHY2139 Material Chemistry Laboratory
5. PHY2160 Electronics

GE – IV & Lab

1. MAS3240 Design of Experiment
2. MAS3230 Lab on Design of Experiment
3. CHY3260 Biophysical Chemistry
4. CHY3238 Applied Chemistry Laboratory
5. PHY3260 Modern Physics

Open Electives (OE)

1. MAS0051: Combinatorics and Probability
2. MAS0052: Everyday Excel – Part 1
3. MAS0053: Linear Algebra
4. MAS2080: Introduction to Astronomical Science
5. MAS2081: Regression Analysis and Forecasting
6. MAS2082: Biostatistics
7. MAS2083: Coding Theory
8. MAS2084: Mathematical Modelling and Computation
9. MAS3080: Marketing Research and Analysis
10. MAS3081: Mathematical Finance
11. MAS3082: Modelling & Simulation
12. MAS3083: Optimization Techniques

Detailed Syllabus: B. Sc. (Hons) Mathematics (2025-28)		
MAS1110	Fundamental of Calculus (4)	Limits, Continuity and Mean Value Theorem: Definition of limit and continuity, types of discontinuities, properties of continuous functions on a closed interval, differentiability, Rolle's theorem, Lagrange's and Cauchy's first mean value theorems, Taylor's theorem (Lagrange's form), Maclaurin's theorem and expansions, convexity, concavity and curvature of plane curves, Formula for radius of curvature in Cartesian, parametric, polar and pedal Forms, Centre of curvature, evolutes and involutes, envelopes, asymptotes, singular points, cusp, node and conjugate points, tracing of standard Cartesian, polar and parametric curves; Partial Differentiation: First and higher order derivatives, Euler's theorem, total derivative, differentiation of implicit functions and composite functions, Taylor's theorem for functions of two variables; Maxima & Minima: Maxima-minima for functions of two variables, necessary and sufficient condition for extreme points, Lagrange multipliers; Integral Calculus: Reduction formulae, application of integral calculus, length of arcs, surface areas and volumes of solids of revolutions for standard curves in Cartesian and polar forms; Beta and Gamma Functions: Beta and Gamma functions and relation between them, evaluation of integrals using Beta and Gamma functions. **References:** 1.S. Narayan and P. K. Mittal, Differential Calculus, S. Chand Publication, New Delhi, 2011. 2.P. Saxena, Differential Calculus, Tata McGraw Hill, New Delhi, 2014. 3.D. V. Widder, Calculus, PHI publication, New Delhi, 2012. 4.S. Narayanan, T. K. Manicavachagom and Pillay, Calculus I & II, S. Viswanathan Pvt. Ltd., Chennai,2010. 5.M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus, Dorling Kindersley Pvt. Ltd., New Delhi, 2007.

MAS1211	Group Theory	Group Theory: Binary operation on a set, algebraic structure, definition of a group, abelian group, finite and infinite groups, order of a group, properties of groups, addition modulo m, multiplication modulo p, residue classes of the set of integers; Permutations: Groups of permutations, cyclic permutation, even and odd permutations, integral powers of an element of a group, order of an element of a group; Subgroups: Intersection of subgroups, cosets, Lagrange's theorem, Euler's theorem, Fermat's theorem, order of the

		product of two subgroups of finite order, Cayley's theorem, cyclic groups, subgroup generated by a subset of a group, generating system of group; Normal Subgroups: Conjugate elements, characteristics subgroup normalizer of an element of a group, class equation of a group, centre of a group, conjugate subgroups, invariant subgroups, quotient groups; Isomorphism and Homomorphism of Groups: Kernel of a homomorphism; fundamental theorem on homomorphism of groups, automorphisms of a group, inner automorphisms, results on group homomorphism, maximal subgroups. **References:** 1.P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, 2nd edition, Cambridge University Press, 1994, reprint 2009. 2.N. S. Gopalakrishanan, University Algebra, New Age International (P) Ltd., 3rd edition, 2015. 3.Vijay K Khanna and S K Bhambri, A Course in Abstract Algebra, 4th edition, Vikas Publication House PVT Ltd, 2013. 4.J.B. Fraleigh, A first Course in Abstract Algebra, Pearson Education Limited, 2013. 5.I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 2013. 6.J. A. Gallian, Contemporary Abstract Algebra, Cengage learning, 2013.
MAS1212	Ordinary Differential Equations (Minor)	Ordinary Differential Equations: Order and degree of a differential equation, formation of differential equations, general, particular and singular solution, Wronskian, its properties and applications; Equations of First Order and First Degree: Separation of variables method, homogeneous equations, equations reducible to homogeneous form, linear equations and equations reducible to linear form, exact equations, equations reducible to exact form, orthogonal trajectories in Cartesian coordinates, Equations of First Order and Higher Degree: Equations solvable for x, y and p, Clairaut's and Lagrange's equation, equations reducible to Clairaut's form, Singular solution; Homogeneous linear differential equations, Simultaneous differential equations, Exact linear differential equations of nth order. Existence and uniqueness theorem. Higher Order Linear Differential Equations: Higher order linear differential equations with constant coefficients. Linear differential equation of second order with variable coefficients. Linear independence of solutions, Solution by transformation of the equation by changing the dependent variables, changing the dependent variables coefficients, Factorization of operators, Method of variation of parameter and Method of undetermined coefficients. **References:** 1.J. L. Bansal, S. L. Bhargava and S. M. Agarwal, Differential Equations, Jaipur Publishing House, Jaipur, 2012. 2.M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Comp., New Delhi, 2013.

		3.S. L. Ross, Differential Equations, Wiley India, New Delhi, 2013. 4.E.A. Coddington, An Introduction to Ordinary Differential Equations, PHI Publication, New Delhi, 2011. 5.Frank Ayres, Theory and problems of Differential Equations, TMH, 2002. 6.G. F. Simmons, Differential Equations, Tata McGraw-Hill, 2006.
MAS1213	Indian Knowledge System	Indian Knowledge System – Introduction, The Vedic Corpus: Introduction to Vedas; A synopsis of the four Vedas; Sub-classification of Vedas; Messages in Vedas; Vedic Mathematics: Introduction to Vedic mathematics, Vedic sutras, Arithmetic Computations, Multiplication: Practical Application in "Compound Multiplication", practice and proportion in Compound Multiplication. Division by the Nikhilam method, Division by Paravartya method, Argumental Division. Factorization (of simple & Harder Quadratic both). **Reference:** 1.Agrawal, V. S. (2015). Vedic Mathematics. Delhi: Motilal Banarsidass Publication. 2.Bharucha D. (2023). Vedic Mathematics, Edukeen Publisher. 3.Mahadevan, B., Balasubramanian, K., & Ganesh, R. (2019). Introduction to Indian Knowledge System: Concepts and Applications, (1st ed.). PHI Learning. 4.Dalal, R. (2013). The Vedas: An Introduction to Hinduism's Sacred Texts. Penguin India. 5.Wadekar, M. L. (2016). Essentials of Vedic Literature. National Book Trust. 6.Macdonell, A. A. (2004). A Vedic Reader for Students (2nd ed.). Motilal Banarsidass.

MAS2112	Real Analysis (4)	Real Numbers: Field structure and order structure, order properties of R and Q, characterization of interval, bounded and unbounded sets, supremum and infimum, order completeness property, archimedean property, density of rational numbers in R, density theorem, characterization of intervals, absolute value of a real number, neighborhoods, open sets, closed sets, limit points of a set, Bolzano-Weierstrass theorem, isolated points, closure, nested interval, cantor nested interval theorem, cover of a set, compact set, Heine-Borel theorem, idea of countable sets, uncountable sets and uncountability of R; Real Sequences: Sequences, bounded sequences, convergence of sequences, limit point of a sequence, Bolzano-Weierstrass theorem for sequences, limits superior and limits inferior, Cauchy's general principle of convergence, Cauchy sequences and their convergence criterion; Algebra of Sequences: Cauchy's first and second theorems and other related theorems, monotonic sequences, subsequences; Infinite Series: Definition of infinite series, Sequence of partial sums, convergence and divergence of infinite series, Cauchy's general principle of convergence for series, positive term series, geometric series, comparison series; Comparison Tests: Cauchy's nth root test; Ratio test, Raabe's test, Logarithmic

		test, Cauchy's Integral test, Gauss test, alternating series and Leibnitz's theorem, absolute and conditional convergence. **References:** 1.S. C. Malik and S. Arora, Mathematical Analysis, New Age Int. Pub., New Delhi, 2017. 2.Shanti Narayan, Elements of Real Analysis, S. Chand & Co., New Delhi, 2015. 3.R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd edition, John Wiley & Sons, 2011. 4.W. Rudin, Principles of Mathematical Analysis, 3rd edition, McGraw Hill, New York, 2013. 5.H. L. Royden and P. M. Fitzpatrick, Real Analysis, 3rd edition, Macmillan, New York, 2010. 6.T. M. Apostal, Mathematical Analysis, Addison-Wesley, 2008. 7.R. R. Goldberg, Methods of Real Analysis, John Wiley & Sons, 2012.
MAS2113	Ring and Field Theory (4)	Rings: Zero divisors, commutative ring with identity, integral domains, division rings, subrings and ideals, congruence modulo a subring relation in a ring, simple ring, algebra of ideals, ideal generated by a subset, quotient rings, prime and maximal ideals, homomorphism in rings, natural homomorphism, kernel of a homomorphism, fundamental theorem of homomorphism, first and second isomorphism theorems, field of quotients, embedding of rings, ring of endomorphisms of an abelian group; Factorization in Integral Domains: Prime and irreducible elements, H.C.F. and L.C.M. of two elements of a ring, principal ideals domains, euclidean domains, unique factorisation domains, polynomials rings, algebraic and transcendental elements over a ring, Factorization in polynomial ring R[x], division algorithm in R[x] where R is a commutative; Ring With Identity: Properties of polynomial ring R[x] if R is a field or a U.F.D., Gauss lemma, Gauss Theorem and related examples; Field: Field extensions, finite field extensions, finitely generated extensions of a field, simple extension of a field, algebraic extension of a field, splitting (Decomposition) fields, multiple roots, normal and separable extension of a field. **References:** 1.S. Singh, Q. Zameeruddin, Modern Algebra, Vikas Pub. House Pvt Limited, 2009. 2.J.B. Fraleigh, A first Course in Abstract Algebra, Pearson Education Limited, 2013. 3.J. A. Gallian, Contemporary Abstract Algebra, 9th edition, Cengage Learning, USA, 2010. 4.I.T. Adamson, Introduction to Field Theory, New edition, Cambridge University Press; 2012.
MAS2114	Linear Programming Problems (4)	Linear Programming Problems (LPP): Introduction, formulation of an LPP, Graphical method of solution of LPP, Areas of application of linear programming; Optimal Solution: Definitions, convex combination and convex set, extreme point, convex hull and convex polyhedron; Simplex Method: Fundamental theorem of linear programming, reduction of a feasible solution to a basic feasible solution,

		optimality condition, unboundedness, simplex algorithm, simplex method for maximization case of an LPP, minimization case- Big M method, Two phase method; Duality: concept of duality, mathematical formulation of duals-construction of duals, duality and simplex method; Dual Simplex Method: Introduction, dual simplex method, computational procedure of the dual simplex algorithm, initial basic solution; Transportation Problem: Introduction, mathematical formulation, initial solution by North West corner rule, Least Cost Method and Vogel's approximation method (VAM), MODI's method for testing optimality, special cases of transportation problem; Assignment Problem: Mathematical formulation, Hungarian method to find optimal assignment, unbalanced assignment problem. **References:** 1.J. G. Chakraborty and P. R. Ghosh, Linear Programming and Game Theory, Maulik Library, Kolkata, 2010. 2.J. K. Sharma, Operations Research, Macmilan Pub. India Ltd., 2013. 3.Kanti Swarup, Gupta, P.K. and Manmohan, Operations Research, 13th edition, Sultan Chand and Sons, 2007. 4.H. A. Taha, Operations Research – An Introduction, 6th edition, Prentice Hall of India, New Delhi, India, 2000. 5.V. K. Kapoor, Operations Research, Sultan Chand & Sons., New Delhi, India, 2005. 6.S. D. Sharma, Operations Research, Kedarnath Ramnath, Meerut, 2018. 7.G. Hadley, Linear Programming, Narosa Publications, 2002.
MAS2126	Basics of Number Theory (2)	Linear Diophantine Equation: prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese remainder theorem, Fermat's little theorem, Wilson's theorem; Number Theoretic Functions: sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Möbius inversion formula, the greatest integer function; Euler's Phi-Function: Euler's theorem, reduced set of residues, some properties of Euler's phi-function. Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots; Euler's Criterion: the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli, public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat's last theorem. **References:** 1. Shirali and Yog, Number Theory, Orient Blackswan Private Limited, New Delhi, 2003. 2. N. Robinns, Beginning Number Theory, Narosa Publishing House Pvt. Limited, Delhi, 2007. 3. D. M. Burton, Elementary Number Theory, Tata McGraw-Hill Edition, Indian reprint, 2007. 4. G. E. Andrew, Number Theory, Revised Edition, Dover Publications, 2012.

MAS2127	Introduction to Higher Trigonometry (2)	Complex Numbers: Introduction of complex numbers, properties of complex numbers, geometrical representation of a complex number, geometrical interpretation of complex numbers; De Moivre's Theorem: Statement and proof of De Moivre's theorem for integral indices, alternative method, Proof for rational indices ,all possible values of $(cosx + i\ sinx)^{p/q}$, application of De-Moivre's theorem for integral and fractional indices ; Trigonometric Functions: Circular trigonometric functions, trigonometric functions of related angles, properties of trigonometric functions, trigonometric identities, inverse functions, summation of series; Hyperbolic and Exponential Functions: Definitions of exponential and hyperbolic functions, laws of exponential and hyperbolic functions; Inverse functions, Summation of series; Logarithm: Definition, properties of logarithms, change of base, two systems of logarithms, use of logarithmic table, antilogarithms, Exponential and logarithmic series. **References:** 1. R. Mazumdar, A. Dasgupta and S. B. Prasad, Degree Level Trigonometry, Bharti Bhawan, Patna, 2012. 2. Lalji Prasad, Higher Trigonometry, Paramount publications, Patna, 2016. 3. V. K. Parashar, Applied Mathematics, Galgotia Publications pvt. Ltd, 2005. 4. S. L. Loney, Plane Trigonometry, University of Michigan Library, 2005. 5. R. K. Ghosh and K. C. Maity, Higher Algebra, New Central Book Agency, Kolkata, 2013. 6. T. Veerarajan and T. Ramachandran, Numerical Methods, Tata McGraw Hill, New Delhi, 2009. 7. W. G. Kelley and A. C. Peterson, Difference equations an introduction with applications, 2nd edition, Harcourt Academic Press, USA, 2001.
MAS2140	**GE – III (A) & Lab** Distribution Theory (3)	Discrete Probability Distributions: Bernoulli distribution, Binominal distributions, Poisson distribution, Poisson distribution as a limiting case of Binomial distribution, Negative Binominal distribution, Geometric distribution, Hyper-geometric distribution and their properties; Continuous Probability Distribution: Uniform distribution, Normal distribution, Exponential distribution, Beta distribution, Gamma distribution, Cauchy distribution and their properties; Limit Laws: Convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution, weak law of large numbers (WLLN), strong law of large numbers (SLLN), De-Moivre-Laplace theorem, central limit theorem (C.L.T.) for i.i.d. variates, Liapunov theorem and applications of C.L.T. **References:** 1.A.M. Goon, A.K. Gupta, and B. Dasgupta, Fundamental of Statistics, Vol. I, World Press, Calcutta, 2005.

		2.A.M. Mood, F.A. Greybill, and D.C. Bose, Introduction to the Theory of Statistics, McGraw Hill, 2001. 3.S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Co., 3rd edition, New Delhi, 2008. 4.W. Feller, An Introduction to Probability Theory and Its Applications, Vol. 1, 3rd edition, John Wiley, 2005. 5.P. Mukhopadhyay, Mathematical Statistics, Books & Allied Ltd., 2009. 6.N.L Johnson, S. Kotz and A.W Kemp, Univariate discrete distributions, John Wiley, 1992. 7.N. L Johnson, S. Kotz and N Balakrishnan. Continuous Univariate distributions I & II, John Wiley, 1991. 8.S. Kotz, N. Balakrishnan and N.L. Johnson. Continuous Multivariate distributions, John Wiley and sons, 2000.
MAS2130	Lab on Distribution Theory (2)	The following practical will be performed using statistical software: Fitting of the Binomial distribution, Poisson distribution, Geometric distribution, Negative Binomial distribution, Multinomial distribution, Hyper-geometric distribution, Uniform distribution, Normal distribution, Exponential distribution, Beta distribution, Gamma distribution, Weilbul distribution and Cauchy distribution. **References:** 1.M. J. Crawley, Statistics: An Introduction Using R, Wiley, 2015. 2.Gopal K. Kanji, 100 Statistical Tests, SAGE Publication, 3rd edition, 2006.
MAS2141	**GE – III (B) & Lab** Sampling Theory (3)	Introduction: Concept of population and sample, need for sampling, complete enumeration versus sampling, basic concepts in sampling, sampling and non-sampling errors, acquaintance with the working (questionnaires, sampling design, methods followed in field investigation, principal findings, etc.) of NSSO and other agencies under taking sample surveys; Simple Random Sampling With or Without Replacement: Estimation of mean, total, variance, proportion, equivalence of different definitions, sample size problem; Stratified Sampling: Estimation of mean, total, proportion and optimum allocation, comparison with simple random sampling without replacement, post stratification; Systematic Sampling Scheme: Linear and circular systematic sampling, comparison with SRS and stratified sampling schemes, linear trend, simple method of variance; Cluster Sampling: Estimation of mean and total, relative efficiency and its estimation, optimum unit of sampling and multipurpose surveys, result on equal and unequal clusters; Two Stage Sampling: results on equal and unequal first sampling unit, allocation of sample, comparison with one stage sampling, effect of change in size of first sampling unit. **References:**

		1.S. Singh, Advanced Sampling Theory and Applications, Springer Science Business Media, 2003. 2.P. Mukhopadhyay, Theory and Methods of Survey Sampling, New Delhi, 2015. 3.D. Singh and F.S. Chaudhary, Theory and Analysis of Sample Survey Designs, New Age International Publication, 2018. 4.S. Sampath, Sampling Theory and Methods, Narosa Publishing House, New Delhi, 2000. 5.Des Raj, Sample Survey Theory, Narosa Publishing House, New Delhi, 2000. 6.W.G. Cochran, Sampling Techniques, John Wiley and Sons, New York, 1977. 7.P.V. Sukhtme, B.V. Sukhatme, S. Sukhatme, and C. Ashok, Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi, 1984
MAS2131	Lab on Sampling Theory (2)	The following practical will be performed using statistical software: Estimation of population mean and variance of estimator under simple random sampling, systematic sampling stratified random sampling, cluster sampling and two stage sampling. **References:** 1.M. J. Crawley, Statistics: An Introduction Using R, Wiley, 2015. 2.G. K. Kanji, 100 Statistical Tests, SAGE Publication, 3rd edition, 2006.

MAS2211	Multivariate Calculus	Limit, Continuity of Function of Several Variables and Partial Derivatives: Introduction to function of several variables, limit of function of several variables, iterated limits, limit and path, continuity of function of several variables; Differentiability of Function of Several Variables: directional derivatives, Introduction to partial derivatives, notations and geometric interpretation, higher order partial derivatives and problems, differentiability of function of two variables, theorems on differentiability conditions, chain rules for differentiability, derivatives of implicit functions, homogeneous functions, Euler's theorem for homogeneous functions of n-variables, Extreme values of functions of two variables, Lagrange's method of undetermined multipliers; Multiple Integrals: Double integration over rectangular region and nonrectangular region, double integrals in polar co-ordinates, triple integrals, Volume by triple integrals, cylindrical and spherical co-ordinates, change of variables in double integrals and triple integrals. **References:** 1.S. Narayan & P.K. Mittal, Differential Calculus, S. Chand Publication, New Delhi, 2011. 2.T. M. Apostol, Advanced Calculus Volume II, Wiley India Publication, Delhi, 2007. 3.S. R. Ghorpade & B. V. Limaye, A course in Multivariable Calculus & Analysis, Springer India, 2014. 4.David V. Widder, Calculus, PHI, New Delhi, India, 2012.

		5.M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus, Dorling Kindersley Pvt.Ltd., New Delhi, 2007.
MAS2212	PDE & System of ODE	Partial Differential Equations: Formation, order & degree, linear and non-linear partial differential equations of the first order, complete solution, singular solution, general solution, solution of Lagrange's linear equations, charpit's general method of solution; Linear Partial Differential Equations of Second and Higher Orders: Linear and non-linear homogeneous and non-homogeneous equations with constant coefficients, partial differential equation with variable coefficients reducible to equations with constant coefficients, their complimentary functions and particular integrals, equations reducible to linear equations with constant coefficients. classification of linear partial differential equations of second order, hyperbolic, parabolic and elliptic types, reduction of second order linear partial differential equations to canonical (normal) forms and their solutions, solution of linear hyperbolic equations, Monge's method for partial differential equations of second order. Cauchy's problem for second order partial differential equations, characteristic equations and characteristic curves of second order partial differential equation, method of separation of variables; Systems of Linear Differential Equations: Types of linear systems, differential operators, an operator method for linear systems with constant coefficients, basic theory of linear systems in normal form, homogeneous linear systems with constant coefficients, two equations in two unknown functions, the method of successive approximations. **References:** 1.D. A. Murray, Introductory Course on Differential Equations, Orient Longman, 2005. 2.M. D. Raisinghania, Ordinary and Partial differential equations, S. Chand, India, 2018. 3.Frank Ayres, Theory and Problems of Differential Equations, McGraw Hill Book Company, 1972. 4.A.R. Forsyth, A Treatise on Differential Equations, Macmillan and Co. Ltd. 5.I. N. Sneddon, Elements of Partial Differential Equations, Tata McGraw Hill Book Company, 1998. 6.Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, Inc., New York, 2016. 7.S. L. Ross, Differential equations, 3rd edition, John Wiley and Sons, India,2004
MAS2213	Linear Algebra	Vector spaces: Subspaces, linear dependence, independence, linear span and basis, dimension of a vector space; Linear Transformations: definition, some results on linear operator, different types of transformations, rank and nullity, singular and non-singular transformations, inverse linear transformation, isomorphism between vector spaces, linear mapping, composition of linear maps; Matrices: Symmetric, skew symmetric matrices, hermitian and skew hermitian matrices, row and column matrices, elementary operations on matrices, rank of a matrix; eigen values, eigen vectors and the characteristic equation of a matrix, Cayley Hamilton theorem and its application in finding inverse of a matrix, applications of matrices to a system of linear equations (both homogeneous and non-homogeneous), theorems on consistency of a system of linear equations; Representation of Transformations by Matrices: Introduction, determination of linear transformation for a given matrix and bases, matrix identity and zero transformations, linear operations on

		Mm□n, matrix of the composition of linear transformations, polynomials of a linear transformation, rank and nullity of matrix, range of a matrix, kernel of a matrix, matrix of change of basis. **References:** 1.K. B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd, New Delhi, 2007. 2.P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, First course in Linear Algebra, New Age International Ltd, 2012. 3.K. Hoffman and R. Kunze, Linear Algebra, 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey, 2014. 4.S. Kumaresan, Linear Algebra-A geometric approach, Prentice Hall of India, 2000. 5.R. B. Dash and D. K. Dalai, Fundamentals of Linear Algebra, Himalaya Publishing house, 2008. 6.Serge Lang, Linear Algebra, 3rd edition, Springer-Verlag, New York 2005.
MAS2218	Vector Calculus & Metric Space	Vector algebra: Addition; Scalar multiplication; Scalar products; Vector product; Scalar and vector triple products; Product of four vectors; Reciprocal vectors; Geometrical applications: Vector equations of lines and planes; Parametric representation of a curve; The circle and other conic sections; Notions of a vector function of a single variable. Vector calculus: Vector differentiation; Total differential; Gradient; Divergence and curl; Directional derivatives; Laplacian operator. Vector integration: Path, line, surface and volume integrals; Line integrals of linear differential forms; Integration of total differentials; Conservative fields; Conditions for line integrals to depend only on the end-points; The fundamental theorem on exact differentials; Theorems of green, Gauss, Stokes, and problems based on these. Basic Definition: metric spaces, open spheres and closed spheres, neighbourhood of a point, open sets, interior points, limit points, closed sets and closure of a set, boundary points, diameter of a set, subspace of a metric space, convergent and Cauchy sequences, complete metric space, dense subsets and separable spaces, nowhere dense sets, continuous functions and their characterizations; Isometry and Homeomorphism: Compact spaces, sequential compactness and Bolzano-Weierstrass property, finite intersection property, continuous functions and compact sets. disconnected and connected sets, components, continuous functions and connected sets. **References:** 1. A.R. Vasishtha, Text Book on Vectors, Krishna Prakashan, Meerut, U.P., India, 2014. 2. Shanti Narayan and P. K. Mittal, A Text Book of Vector Calculus, S. Chand & Company Pvt. Ltd, New Delhi, 2009. 3. J. E. Marsden and A. Tromba, Vector Calculus, 5th Edition, W. H. Freeman, 2003. 4. E. Kreyszig, Advanced Engineering Mathematics, 8th Edition, Wiley India Pvt. Ltd., 2010. 5. T. Apostal, Calculus, Vol. I&II, 2nd Edition, Wiley Students Edition, India, 2012. 6. S. C. Malik and S. Arora, Mathematical Analysis, New Age Int. Pub., New Delhi, 2017. 7. Shanti Narayan, Elements of Real Analysis, S. Chand & Co., New Delhi, 2015. 8. P.K. Jain and Khalil Ahmad, Metric spaces, Second Edition, Narosa Publishing House, New Delhi, 2003.

		9. S. Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag London, 2009. 10. B. K. Tyagi, First Course in Metric Spaces, Cambridge University Press, 2010. 11. K.C. Sarangi, Real Analysis and Matric Spaces, Ramesh Book Depot, 2016. s 12. E.T. Copson, Metric spaces, Cambridge University Press, 1968.
MAS2226	Analytical Geometry of Three Dimensions	Line and Plane: Direction cosines of a line, direction ratios of the join of two points, projection on a line, angle between the lines, equation of line in different forms, equation of a plane in different forms, angle between two planes, line of intersection of two planes, angle between a line and a Plane; Sphere: Definition, equation of a sphere, general equation of a sphere, great circle, equation of circle, tangent line and tangent plane of a sphere, condition of tangency for a line and equation of tangent plane, angle of intersection of two spheres, condition of orthogonality of two spheres; Cone: Cone, quadratic cone, equation of a cone, enveloping cone, condition for general equation of second degree to represent a cone, intersection with a line, tangent plane, reciprocal cone, right circular cone; Cylinder: Definition, equation of a cylinder, enveloping cylinder, equation of enveloping cylinder, right circular cylinder, equation of right circular cylinder; Central Conicoids : Conicoids, central conicoid, standard equation of ellipsoid, hyperboloid of one sheet and hyperboloid of two sheets, nature and shape of central conicoids, tangent line and tangent planes, condition of tangency. **References:** S. L. Loney, The Elements of Coordinate Geometry, Macmillan and Co., London, 2001. 2. P. K. Jain and Khalil Ahmad, A textbook of Analytical Geometry of Three Dimensions, Wiley Eastern Ltd, 2008. 3. R. J. T. Bell, Elementary Treatise on Coordinate Geometry of Three Dimensions, Macmillan India Ltd, 1998. 4. N. Saran and R. S. Gupta, Analytical Geometry of Three Dimensions, Pothisala Pvt. Ltd, Allahabad, 2001. 5. Gorakh Prasad and H. C. Gupta, Textbook on Coordinate Geometry, Pothisala Pvt. Ltd., Allahabad, 2004. 6. Sharma & Jain, Co-ordinate Geometry, Galgotia Publication, Dariyaganj, New Delhi, 1998. 7. Shanthi Narayan, Analytical Solid Geometry, New Delhi: S. Chand and Co. Pvt. Ltd., 2004.
MAS2240	**DSE – I**	Estimation: Parametric space, sample space; Point Estimation: Properties of good estimator: Consistency, unbiasedness, efficiency, sufficiency. Neymann factorization theorem, complete sufficient statistics, minimum – variance unbiased (MVU) estimators, exponential family of distributions and its properties, Cramer- Rao inequality, minimum variance bound (MVB) estimators; Interval Estimation: Confidence intervals for the parameters of various distributions, confidence intervals for difference of means and for ratio

	Statistical Inference	of variances; Methods of Estimation: Method of maximum likelihood, methods of moments; Elements of Statistical Decision Theory: Neyman theory of testing of hypotheses, simple and composite hypotheses, null and alternative hypotheses, two types of errors, critical region, level of significance, power of the test, unbiased tests, Neyman- Pearson lemma, construction of most powerful test, uniformly most powerful test, uniformly most powerful unbiased test; Tests of Significance: tests of significance based on t, F and Chi-square distributions. **References:** 1.A.M. Goon, M.K. Gupta and B. Dasgupta, An Outline of Statistical Theory, Vol. II, 3rd edition, World Press, Kolkata, 2005. 2.M Kendall, A. Stuart and J.K. Ord, Kendall's Advanced Theory of Statistics, Oxford University Press, 5th edition, 1991. 3.P. Mukhopadhyay, Applied Statistics, Books & Allied Ltd., 2011. 4.G. Casella, and R.L. Berger, Statistical Inference, Second Edn. Thomson Duxbury, 2002. 5.R.V. Hogg, and E.A. Tanis, Probability and Statistical Inference, 9th edition, Macmillan Publishing Co. Inc., 2014. 6.V. K. Rohatgi, Statistical Inference, John Wiley and Sons, 2003.
MAS2230	Lab on Statistical Inference	The following practical will be performed using statistical software: Method of maximum likelihood, methods of moments, minimum chi- square and modified minimum chi- square, computation of confidence intervals for the parameters of various distributions, confidence intervals for difference of means and for ratio of variances, confidence interval for binomial proportion and population correlation coefficient when population is normal. **References:** 1.M. J. Crawley, Statistics: An Introduction Using R, Wiley, 2015. 2.Gopal K. Kanji, 100 Statistical Tests, SAGE Publication, 3rd edition, 2006.

MAS3101	Numerical Analysis (3)	Errors in Numerical Computing: Introductions, types of errors; Numerical Solution of Algebraic and Transcendental Equations: Bisection method, Regula falsi method, Secant method, Iteration method, Newton-Raphson method, Bairstow's method, synthetic division scheme; Solution of Linear System of Equations: Gauss elimination method, Gauss Jordan method, Crout's method, Cholesky method, Gauss Jacobi method,

		Gauss Seidel method; Finite Differences: Finite difference operators, relation between difference operators, Lagrange and Newton-divided interpolation, Newton -Gregory forward and backward interpolation, central interpolation, Stirling formulae; Numerical Differentiation and Integration: Numerical differentiation of Newton's forward and backward formula, Newton's Cotes-quadrature formula, numerical integration by trapezoidal rule, Simpson's rule – 1/3rd and 3/8th rule. Weddle rule; Numerical Solution of Ordinary Differential Equations (for first order only): Picard's method, Euler's method, Modified Euler method, Taylor series method, Runge-Kutta methods. **References:** 1.G. Haribhaskaran, Numerical Methods, Laxmi Publications, Delhi, 2008. 2.M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International, 2013. 3.H.C Saxena, Finite Differences and Numerical Analysis, S. Chand & Company Ltd., New Delhi, 2015. 4.M. K. Venkataraman, Numerical Methods in Science and Engineering, National Publishing Company, 6th Edition, 2012. 5.K. Sankara Rao, Numerical Methods for Scientists and Engineers, 2nd edition, Prentice Hall India, 2004. 6.P. Kandasamy, Numerical Methods, S. Chand & Co., New Delhi, 2007.
MAS3103	Dynamics (4)	Kinematics and Kinetics: Fundamental notions and principles of dynamics, Laws of motion, Relative velocity; Kinematics: Radial, transverse, tangential, normal velocities and accelerations, Simple harmonic motion, repulsion from a fixed pint, motion under inverse square law, Hooke's law, horizontal and vertical elastic strings, motion on an inclined plane, motion of a projectile, work, energy and impulse, conservation of linear momentum, principle of conservation of energy, uniform circular motion, motion on a smooth curve in a vertical plane, motion on the inside of a smooth vertical circle, cycloidal motion, motion in the resisting medium, resistance varies as velocity and square of velocity; Central Forces: Stability of nearly circular orbits, Kepler's laws, time of describing an arc and area of any orbit, slightly disturbed orbits. **References:** 1.P. S. Deshwal, Particle Dynamics, New Age International, New Delhi, 2000. 2.M. Ray and G. C. Sharma, A Textbook on Dynamics, S. Chand and Co., 2010. 3.A. S. Ramsey, Dynamics, Cambridge University Press, 2009. 4.S. L. Loney, An Elementary Treatise on the Dynamics of a Particle, Cambridge University Press, 2013.
MAS3104	Integral Transforms (4)	Laplace transform: Definition, Basic properties, Laplace transforms for improper integral, Laplace transform of derivatives and integrals, Multiplication and division by power of independent variable, Evaluation of integrals by using Laplace transforms, Periodic functions, Initial-value and Final value theorem. Inverse Laplace transform: Definition, Basic properties, Inverse Laplace transform of derivatives and integrals, Multiplication and division by power of independent variable, Convolution theorem for Laplace transform, Evaluation of integrals by using inverse Laplace transform, Use of partial fractions, Heaviside expansion

		formula. Fourier transform: Definition and properties of Fourier complex sine, cosine and complex transforms, Inversion theorem, Relationship between Fourier transform and Laplace transform, Modulation theorem, Convolution theorem for sine, cosine and complex transforms, Parseval's identity, Fourier transform of derivatives. Mellin transform: Definition and elementary properties, Mellin transforms of derivatives and integrals, Inversion theorem, Convolution theorem, Inverse Mellin transform of two functions. Applications to integral transforms. **References:** 1.Goyal J. K. and Gupta K. P, Laplace and Fourier Transforms, Pragati Prakashan, Meerut, 2006. 2.Vashistha A. R., Gupta, R. K. Integral Transform, Krishna Prakashan Mandir, Meerut, 2016. 3. Baidyanath Patra, An introduction to Integral transform, CRC Press Taylor & Francis Group, 2018.
MAS3130	Lab on Numerical Analysis (2)	The following practical will be performed using C language: Bisection method, Regula falsi method, Secant method, Iteration method, Newton-Raphson method, Gauss elimination method, Gauss Jordan method, Crout's method, Cholesky method, Gauss Jacobi method, Gauss Seidel method, Lagrange and Newton interpolation, Gregory-Newton forward and backward difference interpolation, Central interpolation, Stirling formula, trapezoidal rule, Simpson'srule – 1/3rd and 3/8th rule, Weddle rule, Picard's method, Euler's method, Modified Euler method, Taylor series method, Runge-Kutta methods. **Reference:** 1.K. Das, Numerical Methods Theoretical and Practice, U.N. Dhur & Sons, 2nd edition, 2011.
MAS3170	Project	Project
MAS3141	**DSE – II (A)** Modelling and Simulation (3)	Introduction to Modelling and Simulation: System analysis, classification of systems, system theory basics, its relation to simulation, model classification, conceptual, abstract, and simulation models. heterogeneous models, methodology of model building, simulation systems and languages, means for model and experiment description, Principles of simulation system design, parallel process modelling, using petri nets and finite automata in simulation models of queuing systems, discrete simulation models, model time, simulation experiment control; Continuous System Modelling: Overview of numerical methods used for continuous simulation, combined simulation, role of simulation in digital systems design, special model classes, models of heterogeneous systems; Checking Model Validity: verification of models, analysis of simulation results, simulation results visualization, interactive simulation, design and control of simulation experiments; Model Optimization: Generating, transformation, and testing of pseudorandom numbers, stochastic models, Monte Carlo method, overview of commonly used simulation systems. **References:** 1.S. Ross, Simulation, Academic Press, 5th edition, 2012. 2.A. Law and D. Kelton, Simulation Modelling and Analysis, McGraw-Hill, 5th edition, 2014. 3.P. Fishwick, Simulation Model Design and Execution, Prentice Hall, 1995. 4.B. P. Zeigler, Theory of modelling and simulation, 3rd edition, 2018.

MAS3144	**DSE – II (B)** Operations Research (3)	Operations Research: Origin, definition and scope; Stochastic Process: Introduction, basic concept, 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); Replacement Problems: Introduction, items that deteriorate, items that fail completely/suddenly, system reliability and failure rate; Sequencing: Introduction, solution of processing n jobs through 2 machines, n jobs through 3 machines and n jobs through m machines; 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. **References:** 1.J. K. Sharma, Operations Research and Application, Mc. Millan and Company, New Delhi, 2012. 2.S.D, Sharma, Operations Research, Kedar Nath Ram Nath & Co., 2010. 3.H. A. Taha, Operations Research -An introduction, Prentice Hall of India Pvt. Ltd. New Delhi, 2003. 4.B. Mahadevan, Operation Management: Theory and Practice, Pearson Education India, 2015. 5.K. Swarup, P.K. Gupta and M. Mohan, Operation Research, Sultan Chand & Sons, 2010.

MAS3201	Complex Analysis	Analytic Functions: (Recapitulation) functions of complex variables, mappings, limits, continuity, derivatives, C-R equations, analytic functions; Complex Integration: Complex valued functions, contour, contour integrals, Cauchy- Goursat theorem, Cauchy integral formula, Moreras theorem, Liouvilles theorem, fundamental theorem of algebra; Power Series: Convergence of sequences and series, power series and analytic functions, Taylor series, Laurent's series, absolute and uniform convergence, integration and differentiation of power series, uniqueness of series representation, zeros of an analytic function classification of singularities, behavior of analytic function at an essential singular point; Residues and Poles: Residues, Cauchy – Residue theorem, residues at poles, evaluation of improper integrals, evaluation of definite integrals, the argument principle, Rouche's theorem, Schwarz lemma, maximum modules principle, minimum modules principle, complex form of equations of straight lines, half planes, circles, etc., analytic (holomorphic) function as mappings; conformal maps; Transformations: Mobius transformation, cross ratio, symmetry and orientation principle, examples of images of regions under elementary analytic function. **References:** 1.R.V. Churchill, J.W. Brown, Complex Variables and Applications, 8th edition, McGraw Hill Series, 2008. 2.B. Choudary, The element of Complex Analysis, 2nd edition, Wileys Eastern Ltd., 1983.

		3.J. B. Conway, Functions of one complex variable, Springer International Student edition, Narosa Publishing House, 2000. 4.A. R. Shastri, An Introduction to Complex Analysis, Macmillan India Ltd., 2003. 5.W. Rudin, Real and Complex Analysis, McGraw Hill Series, 1987.
MAS3202	Riemann Integration & Series of Functions	Riemann Integration: Inequalities of upper and lower sums, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two definitions, Riemann integrability of monotone and continuous functions, properties of the Riemann integral, definition and integrability of piecewise continuous and monotone functions, intermediate value theorem for Integrals, fundamental theorems of Calculus; Improper Integrals: Convergence for finite and infinite limits, Convergence of Beta and Gamma functions, pointwise and uniform convergence of sequence of functions; Theorems on Continuity: derivability and integrability of the limit function of a sequence of functions, Series of Functions: Theorems on the continuity and derivability of the sum function of a series of functions, Cauchy criterion for uniform convergence and Weierstrass M-Test, limit superior and limit inferior; Power series: radius of convergence, Cauchy Hadamard theorem, differentiation and integration of power series. **References:** 1.G. Das and S. Pattanayak, Fundamentals of mathematics analysis, TMH Publishing Co., 2016 2.S.C. Mallik and S. Arora, Mathematical analysis, New Age International Ltd., New Delhi, 2012. 3.K. A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer, Indian reprint, 2004. 4.S. Narayan, Elements of real analysis, S. Chand & Co. 2017. 5.R. G. Bartle D.R. Sherbert, Introduction to Real Analysis, 3rd edition, John Wiley and Sons Asia, Pvt. Ltd., Singapore, 2002. 6.C. G. Denlinger, Elements of Real Analysis, Jones & Bartlett, 2011. 7.W. Rudin, Real and Complex Analysis, McGraw Hill Series, 1987.
MAS3204	Statics	Statics: Forces, couples, resultant of two parallel forces, moment, co-planar forces, analytical method, equation to the resultant, equivalent force and couple, two trigonometrical theorems, static equilibrium, friction, law of friction, body in limiting equilibrium on an inclined plane, least force required to pull a body up or down an inclined rough plane, equilibrium of a particle constrained to rest on a rough curve under any given forces, equilibrium of a particle on a rough curve, virtual work; position of equilibrium, principle of virtual work for a system of coplanar forces acting on a particle, unwanted force, tension and thrust, catenary; flexible string, cartesian equation of the common catenary, geometrical properties of common catenary, forces in three dimensions, reduction of a system of forces in space, invariance of the system, general conditions of equilibrium, center of gravity for different bodies, stable and unstable equilibrium. **References:** 1.A. S. Ramsey, Statics, Cambridge University Press, 2nd edition, 2009.

		2.S. L. Loney, The Elements of Statics and Dynamics Part-I, Aitbs publication, 2016
MAS3242	**DSE – III (A)** Numerical Methods for Ordinary and Partial Differential Equations	Ordinary Differential Equations: Initial value problems and existence theorem, truncation error, deriving finite difference equations, single step methods for first order initial value problems, Taylor series method, Euler method, Picard's method of successive approximation, Runge Kutta methods, stability of single step methods, multi-step methods for first order initial value problem, Predictor-Corrector method, Milne and Adams Moulton Predictor corrector method, system of first order ordinary differential equations, higher order initial value problems, stability of multi-step methods, root condition; Boundary Value Problems: finite difference methods, shooting methods, stability, error and convergence analysis, nonlinear boundary value problems; Partial Differential Equations: Classification, Finite difference approximations to partial derivatives, solution of one dimensional heat conduction equation by explicit and implicit schemes, stability and convergence criteria, Laplace equation using standard five point formula and diagonal five point formula, Iterative methods for solving the linear systems, hyperbolic equation, explicit and implicit schemes, method of characteristics, solution of wave equation, solution of first order hyperbolic equation, Von Neumann stability. **References:** 1.K. E. Atkinson, W. Han and D. E. Stewart, Numerical Solution for Ordinary Differential Equations, John Wiley & Sons, New York, 2011. 2.M K Jain, S R K Iyengar and R K Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publication, New Delhi, 2014. 3.G. D. Smith, Numerical Solution of Partial Differential Equations, Oxford University Press, London, 1986.
MAS3245	**DSE – III (B)** Introduction to Graph Theory	Preliminaries: Graphs, isomorphism, subgraphs, matrix representations, degree, operations on graphs, degree sequences; Connected Graph and Shortest Path: Walks, trails, paths, connected graphs, distance, cut-vertices, cut-edges, blocks, connectivity, weighted graphs, shortest path algorithms; Trees: Characterizations, number of trees, minimum spanning trees; Special Classes of Graph: Bipartite graphs, line graphs, chordal graphs; Eulerian Graph: Characterization, Fleury's algorithm, chinese-postman-problem; Hamilton Graphs: Necessary conditions and sufficient conditions independent sets, coverings; Matching: Basic equations, matchings in bipartite graphs, perfect matchings, greedy and approximation algorithms; Vertex Coloring: Chromatic number and cliques, greedy coloring algorithm, coloring of chordal graphs; Planar Graphs: Basic concepts, Eulers formula; Directed Graph: Out-degree, in-degree, connectivity, orientation, Eulerian directed graphs, Hamilton directed graphs. **References:** 1.D. B. West, Introduction to Graph Theory, Prentice Hall of India, 2012. 2.N. Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall, 2009. 3.G. Chatrand and Ping Zhang, Introduction to Graph Theory, McGraw Hill Education, 2017. 4.R. J Wilson, Graph Theory, Prentice Hall, 2010.

MAS3240	**GE – IV & Lab** Design of Experiments	Analysis of Variance: Analysis of Variance for one- way, two -way with one/m observations per cell for fixed, mixed and random effects models, Tukey's test for non- additivity; Design of Experiment: Basic principles of experimental design, general block design and its information matrix, criteria of connectedness, balance and orthogonality, analysis of completely randomized, randomized blocks and Latin-square designs; Factorial Experiments: Symmetrical factorials, 〖2〗^2-experiment and 2^3-experiment. **References:** 1.M.N. Das and N.C. Giri, Design and Analysis of Experiments, Wiley Eastern Ltd, 1986. 2.A.M. Goon, M.K. Gupta and B. Dasgupta, Fundamentals of Statistics, Vol. II, 8th edition. World Press, Kolkata, 2005. 3.S.C. Gupta and V.K. Kapoor, Fundamentals of Applied Statistics, Sultan Chand and Co., 3rd edition, New Delhi, 2008. 4M. D. Morris, Design of Experiment An Introduction Based On Linear Models, Chapman and Hall/CRS, 2017. 5.D. C. Montgomery, Design and Analysis of Experiments, John Wiley, 2008. 6.A. Dey, Theory of Block Design, J. Wiley, 1986.
MAS3230	Lab on Design of Experiment	The following practical will be performed using statistical software: Analysis of for one- way, two -way with one/m observations per cell for fixed, mixed and random effects models, analysis of completely randomized, randomized blocks and Latin-square designs, analysis of 2^2-experiment, 2^3-experiment and 2^n-experiment in 2^k blocks per replicate. **References:** 1. M. J. Crawley, Statistics: An Introduction Using R, Wiley, 2015. 2. Gopal K. Kanji, 100 Statistical Tests, SAGE Publication, 3rd edition, 2006.