Dr. Rammanohar Lohia Avadh University, Ayodhya, U.P.

Structure of Syllabus for the

Programme: M.Sc., Subject: Mathematics (Statistics)

Structure of Syllabus Developed by			
Name of BOS Convener/BOS Members	Designation	Department	College/ University
Prof. Chayan Kumar Mishra	Dean, Faculty of Science	Department of Mathematics and Statistics	Dr. Rammanohar Lohia Avadh University, Ayodhya
Prof. S. S. Mishra	Head and Convener	Department of Mathematics and Statistics	Dr. Rammanohar Lohia Avadh University, Ayodhya
Prof. S. K. Raizada	Professor	Department of Mathematics and Statistics	Dr. Rammanohar Lohia Avadh University, Ayodhya
Dr. Abhishek Singh	Associate Professor	Department of Mathematics and Statistics	Dr. Rammanohar Lohia Avadh University, Ayodhya
Prof. Shri Ram	External Expert	Department of Mathematical Sciences	IIT BHU, Varanasi
Prof. Uma Srivastava	External Expert	Department of Mathematics and Statistics	DDU Gorakhpur University, Gorakhpur
Prof. Arvind Kumar Mishra	External Expert	Department of Mathematics	BHU, Varanasi
Prof. T. B. Singh	External Expert	Institute of Medical Sciences	IMS, BHU, Varanasi
Prof. R. S. Singh	External Expert	Department of Mathematics	Dr. H. S. Gaur University, Sagar, M.P.

Course Code		Course Title	Credits	T/P	Evaluation	
					CIE	ETE
A	B	C	D	E	F	G
SEMESTER I (YEAR I)						
B230701T	CORE	Real Analysis	4	T	25	75
B230702T	CORE	Advanced Abstract Algebra	4	T	25	75
B230703T	CORE	Topology-I	4	T	25	75
B230704T	CORE	Differential Geometry of Manifold	4	T	25	75
B230705T	FIRST	Probability and Statistical Methods	4	T	25	75

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B230706T	ELECTIVE (Subject Elective) (Select any one)	Fuzzy Theory and Its Applications	4	T	25	75
B230707P	SECOND ELECTIVE (Subject Elective) (Select any one)	Computing Lab-I	5	P	50	50
B230708P		Project/Seminar Presentation	5	P	50	50
		SEMESTER II (YEAR I)				
B230801T	CORE	Mathematical Methods	4	T	25	75
B230802T	CORE	Linear Algebra	4	T	25	75
B230803T	CORE	Topology-II	4	T	25	75
B230804T	CORE	Numerical Analysis	4	T	25	75
B230805T	THIRD ELECTIVE (Generic Elective) (Select any one)	Applied Statistics	4	T	25	75
B230806T		Computing Fundamentals	4	T	25	75
B230807P	FOURTH ELECTIVE (Subject Elective) (Select any one)	Computing Lab II	5	P	50	50
B230808P		Project/ Seminar Presentation	5	P	50	50
		SEMESTER III (YEAR II)				
B230901T	CORE	Complex Analysis	4	T	25	75
B230902T	CORE	Operations Research	4	T	25	75
B230903T	CORE	Functional Analysis	4	T	25	75
B230904T	CORE	Special Functions	4	T	25	75
B230905T	FIFTH ELECTIVE (Subject Elective) (Select any one)	Riemannian Manifold	4	T	25	75
B230906T		General Relativity	4	T	25	75
B230907P	SIXTH ELECTIVE (Subject Elective) (Select any one)	Computing Lab III	5	P	50	50
B230908P		Project/Seminar Presentation	5	P	50	50
		SEMESTER IV (YEAR II)				
B231001T	CORE	Ordinary and Partial Differential Equations	4	T	25	75
B231002T	CORE	Advanced Operations Research	4	T	25	75
B231003T	SEVENTH ELECTIVE (Subject Elective) (Select any one)	Graph Theory and Discrete Mathematics	4	T	25	75
B231004T		Demography	4	T	25	75

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B231005T	EIGTH ELECTIVE (Subject Elective) (Select any one)	Advanced Special Functions	4	T	25	75
B231006T		Finsler Geometry	4	T	25	75
B231007T	NINETH ELECTIVE (Subject Elective) (Select any one)	Cosmology	4	T	25	75
B231008T		Advanced Statistical Inference	4	T	25	75
B231009P	RESEARCH PROJECT/ DISSERTATION	Research Project	5	P	50	50

Programme Outcomes (POs)

- To provide higher and advanced conceptual knowledge of mathematics and its relevant branches.
- To suggest appropriate applications of mathematics in diverse applied sciences and engineering etc.
- To apply mathematical skills and techniques to analyze the problems arising out of society and industry etc.
- To get knowledge about pure and applied mathematics and communicate effectively amongst scientific and mathematical fraternity.
- To develop positive attitude towards learning the higher mathematics, logical thinking and problem solving.
- To prepare the proper foundation to undertake research in higher mathematics and to help for solving the problems connected with society and real life problems.
- To demonstrate and maintain the ethical values related to teaching, learning and research of mathematics sciences.

Programme Specific Outcomes (PSOs)

- To develop self learning and improve their own performance.
- To execute research in collaboration with others and individual also.
- To imbibe effective mathematical and technical communication.
- To develop problem solving capacity as well as creativity.
- To produce the mathematics researchers for next generation.
- Apply the knowledge of mathematical concept in interdisciplinary fields.
- To prepare the students to get jobs in schools and colleges as a mathematics teacher, professors also in software industries, research and development organizations.

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: I
Subject: Mathematics (Statistics)		
Course Code: B230701T	Course Title: Real Analysis	

Course outcomes:

1. Students will be able to understand the concept of monotonic functions and its different kind of properties and some properties of function of bounded variation and The Jordan Decomposition

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theorem.

2. Students will able to understand and evaluate Riemann Stieltje's Integral, Fundamental theorem of Calculus and rectifiable curves.
3. They will able to understand the concept of sequences of functions of real numbers, point wise convergence and uniform convergence and different method for analyzing the convergence of sequences of functions.
4. They will able to understand function of several variables, linear transformations, derivatives of higher orders, Taylor's theorem, inverse function theorem.

Credits:4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks: 40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Monotonic functions and its properties, types of discontinuity, Functions of Bounded Variation and some properties of function of bounded variation, total variations, Lipschitz condition and function, Variation function and The Jordan Decomposition theorem.	16
II	Riemann Stieltje's Integral: definition and existence of Integral, Properties of integral, integration and differentiation, Fundamental theorem of calculus, 1st and 2nd mean value theorems for Riemann Stieltje's integral, rectifiable curves.	12
III	Sequences of functions of real numbers, Point wise convergence and uniform convergence, cauchy Criterion of uniform convergence Mn test, Weierstrass M- test, Dini's criterion of uniform convergence, Uniform convergence and continuity, Continuity of limit function, Uniform convergence and Riemann stieltjes integration, Uniform convergence and differentiation, Weierstrass approximation theorem. Power series. Uniqueness theorem for power series, Abel's and Tauber's theorem.	16
IV	Function of Several Variables, Linear transformations, Derivatives in an open subset of Jacobian matrix and Jacobians, Chain rule and its matrix form, Interchange of order of differentiation, Derivatives of higher orders, Taylor's theorem, Inverse function theorem, Implicit function theorem, Extremum problems with constraints, Lagrange's multiplier method	16

Suggested Readings:

1. Rudin, Walter, "Principle of Mathematical Analysis" (3rd edition), McGraw- Hill Kogakusha, International Student Edition, 1976.
2. Apostol, T. M., "Mathematical Analysis", Narosa Publishing House, New Delhi, 1985.
3. Rudin, Walter, "Principles of Mathematical Analysis" (Third Edition), McGraw-Hill, Book Company.
4. Malik S C. and Arora, "Mathematical Analysis", New Age Publication.
5. Goffman, C, "Calculus of Several Variables", Harper and Row.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics

in B.Sc.
Suggested equivalent online courses: .....
Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: I
Subject: Mathematics (Statistics)		
Course Code: B230702T	Course Title: Advanced Abstract Algebra	

Course outcomes:

1. Able to understand the advanced Group studies, most particularly series of groups & Jordan Holder Theorem, Schreier Theorem and applications.
2. Able to understand & describe the concept of Algebraic extensions, Normal extensions also Primitive element theorem & their applications in various branches of mathematics.
3. Able to understand and apply the concepts of Galois Groups, its Extensions and Fundamental theorem of Galois theory.
4. Able to understand and apply Artin's Theorem, Fundamental theorem of Algebra, constructability in every day geometrical problems.

Credits:4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Group Theory: Permutation groups, Cayley's theorem, Pigeon-hole principle, Induction exclusion principle, Degrangements, class equation of a finite group, series of groups, Schreier theorem, Jordan holder theorem, Solvable groups, p-sylow subgroups, Sylow's theorem.	16
II	Extension Field Theory: Extension fields, Algebraic extensions, Finite extension, Splitting fields, Algebraically closed fields, Normal extension, Separable extension, primitive element theorem.	17
III	Galois Theory: Galois groups, Galois extensions, Fundamental theorem of galois theory.	12
IV	Application of Galois Theory: Artin's theorem, Fundamental theorem of algebra (Algebraic proof), Radical extensions, Insolvability of quintic, Constructability.	15

Suggested Readings:

1. Herstein, I. N., "Topics in Algebra"Wiley Eastern Ltd. New Delhi, 1975.
2. Sahai V. and Bist V., . "Algebra", Narosa Publishing House, 1999.
3. Bhattacharya, P. B., Jain, S. K. & Noyapal, S. R., "Basic Abstract Algebra", Cambridge.
4. Hungerford; T. W., "Algebra", Springer.
5. Malik, Mordeson & Sen, "Fundamentals of Abstract Algebra", Tata MaGraw-Hill.
6. Sen, Ghosh & Mukhopadhyay, "Topics in Abstract Algebra", University Press.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks

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Punctuality/ Active Participation: 5 Marks
Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.
Suggested equivalent online courses: .....
Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	**Year: First**	**Semester: I**
Subject: Mathematics(Statistics)		
Course Code: B230703T	**Course Title: Topology I**	

Course outcomes:

1. To understand and illustrate the concept of topological spaces, closed sets, closure, Interior, exterior and boundary of sets, Interior operator, accumulation points and derived sets.
2. Demonstrate the knowledge of understanding bases and sub bases, subspaces and relative topology, hereditary properties, dense sets, separable spaces and their relationships.
3. Apply the use of continuous functions, sequential continuity, open mappings, closed mappings, homeomorphisms to develop topological properties.
4. Analyze and illustrate the concept of compact sets, compact topological space, finite intersection properties, countable compactness and one point compactification.

Credits:4	**Core Compulsory**
Max. Marks: 25+75	**Min. Passing Marks:40**

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0

Unit	Topics	No. of Lectures
I	Definition and examples of topological spaces, closed sets, neighborhoods, properties of neighborhoods and neighborhood systems. Closure, Interior, exterior and boundary of sets, Alternative methods of defining a topology in terms of Kuratowski's closure operator, Interior operator, accumulation points and derived sets.	15
II	Bases and Sub bases, Subspaces and relative topology, Hereditary properties, First and Second countable spaces, Dense sets, Separable spaces and their relationships.	15
III	Continuous functions and Sequential continuity, Open mappings, Closed mappings, Homeomorphism and topological property.	15
IV	Covering of sets and sub cover, compact sets, compact topological space, finite intersection properties, basic and Sub basic open covering, countable compactness and sequential compactness, compactness on the real line, local compactness, lindelof spaces and lindelof theorem, compactification and one point compactification.	15

Suggested Readings:

1. Simmons, G. F., "Introduction to Topology and Modern Analysis", McGraw-Hill, 1963.
2. Kelly J. L., "Topology", Van Nostrand Reinhold Co. New York, 1995.
3. James R. Munkres, "Topology A first courses", Prentice Hall of India Pvt. Ltd. New Delhi, 2000.
4. Dugundji, J., Allyn & Bacon, "Topology", Prentice Hall of India Pvt. Ltd., 1966.

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5. Joshi K. D., "Introduction to General Topology", Willey Eastern Ltd., 1983.
6. Hocking, J. & Young, G., "Topology", Addision-Wesley, Reading, 1961.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:
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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: I
Subject: Mathematics(Statistics)		
Course Code: MMSC105	Course Title: Differential Geometry of Manifolds	

Course outcomes:

1. To understand and apply basic concept of manifolds, Tangent Spaces, vector fields, Jacobian map, distributions, hypersurface of R^n.
2. To learn, understand and apply the covariant derivative and its applications to find the solution of in Gauss curvature equation and Coddazi-Mainardi equations.
3. To learn, understand and apply the Cartan view point in tensor of two connections, Torsion and curvature tensors.
4. To understand and describe Riemannian Manifolds and its curvatures, submanifolds and applications.

Credits:4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0

Unit	Topics	No. of Lectures
I	Definition and examples of differentiable manifolds, Tangent spaces, vector fields, Jacobian map, distributions, hypersurface of R^n.	15
II	Standard connection on R^n, Covariant derivative, Sphere map, Weingarten map, Gauss equation, Gauss curvature equation and Coddazi-Mainardi equations.	15
III	Invariant view point, Cartan view point, Coordinate view point, difference tensor of two connections, torsion and curvature tensors.	16
IV	Riemannian manifolds, length and distance in Riemannian manifolds, Riemannian connection and curvature, curves in Riemannian manifolds, sub manifolds.	14

Suggested Readings:

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1. Hicks, N. J., "Notes on Differential Geometry", D. Van Nostrand, New York, 1965.
2. Matsushima, Y., "Differentiable Manifolds", Marcel Deckker, Inc., New York, 1972.
3. Mishra, R. S., "A Course in Tensors with Applications to Riemannian Geometry", Pothishala (Pvt.) Ltd., India, 1965.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: I
Subject: Mathematics(Statistics)		
Course Code: B230705T	Course Title: Probability and Statistical Methods	

Course outcomes:

1. Able to understand basic concept of probability, Random variables (discrete and continuous) and Baye's theorem, moment generating functions.
2. Able to understand several well known distributions including Binomial, Poisson, Exponential and Normal distribution.
3. Able to understand basic statistical concept mean, median, mode and measures, standard deviation, mean deviation also concept of fitting of curves by method of least square (straight line, parabola and exponential curve).
4. Able to understand the concept of correlation, correlation coefficient, regression, regression coefficient and line of Regression of Yon X and X on Y also non linear regression.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:10

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0

Unit	Topics	No. of Lectures
I	Probability, Introduction addition and multiplication Law of probability, conditional probability, Baye's theorem, Random variables (discrete and continuous), Probability generating functions, Expectations and variance, moments and moment generating functions.	15
II	Discrete and continuous distributions, probability distribution and probabilities densities: Binomial, Poisson, Exponential and normal distribution and their PDF's and MGF's for above distribution functions.	15
III	Introduction, measures of central tendency (Mean, Median, Mode), dispersion (Mean deviation and standard deviation), Skewness,	

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	kurtosis, curve fitting (Fitting of straight lines, second degree parabola and exponential curves) by method of least squares.	15
IV	Correlation, Rank correlation, Regression analysis, line of Regression of Y on X and X on Y, Regression Coefficients, properties of regression coefficients and Non linear regression.	15

Suggested Readings:

1. Gupta, Goon and Gupta Das, "Fundamentals of Statistics" (Vol. II) & I, World Press, 2016.
2. Feller W., "An Introduction to probability Theory", Vol. I, Wiley, 2008.
3. Hoel, P.G., "Introduction to Mathematical Statistics", Wiley; 5th edition, 1984.
4. Lahmann, E.L., "Testing Statistical Hypotheses", Springer, 2008.
5. Rao, C.R., "Linear Statistical Inference and its Applications", Wiley-Interscience, 2nd edition, 2002.
6. Gupta, S.C. and Kapur V.K., "Fundamentals of Applied Statistics", S. Chand & Sons, 1994.
7. Sukhate and Sukhatme, "Sampling", The Indian Society of Agricultural Statistics, 1954.

Suggestive digital platforms web links

This course can be opted as an elective by the students of following subjects: M.Sc. Physics, Electronics. Biochemistry, Microbiology, Environmental Sciences, M.A. (Economics and Rural Development)

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: I
Subject: Mathematics(Statistics)		
Course Code: B230706T	Course Title: Fuzzy theory and its Applications	

Course outcomes:

1. Able to define LPP, formation of LPP and apply simplex methods to find the solution of LPP. Illustrate and understand the concept of duality in LPP.
2. Able to define and understand the transportation problem. By applying NWCR, LCM, VAM to find initial solution of TP. Further optimum solution by MODI method.
3. Illustrate the concept of non-linear programming, constraint optimization, unconstraint optimization and understand Kuhn-Tucker conditions, Kuhn-Tucker conditions for GNLPP with m (<n) constraints, sufficiency of Kuhn-Tucker conditions.
4. Able to define and understand concept of simulation, generate the random numbers by Monte-Carlo simulation and application of simulation.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0

Unit	Topics	No. of Lectures

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I	Fuzzy sets, basic definition, $\propto$ – level sets, convex fuzzy sets, basic operations on fuzzy sets, Types of fuzzy sets, Cartesian product, Algebraic product.	15
II	Bounded sum and difference, t-norms and t-c norms, Extension principle, The Zadeh's extension principle.	15
III	Fuzzy Logic, an overview of classical logic, multivalued logic, fuzzy propositions, fuzzy quantifiers Linguistic variables and hedges, Inference from conditional fuzzy propositions, the compositional rule of inference.	15
IV	Fuzzy expert System, concept and development, an introduction to fuzzy control, fuzzy rule base, fuzzy inference engine, fuzzification, defuzzifications and various defuzzificztion method (the centre of area the centre of maxima and mean of maxima methods).	15

Suggested Readings:

1. Klir J. George and Yuan Bo , "Fuzzy Sets and Fuzzy Logic: Theory and Applications", Pearson, 2015.
2. Bhargava, A. K., "Fuzzy set theory, Fuzzy logic and their applications", S. Chand Pvt Ltd, 2013.
3. Zadeh, L. A., " Fuzzy sets and their applications cognitive and decision processes" Elsevier science publishing, 1975.
4. Zadeh, L. A. and Aliev, A. K., "Fuzzy logic theory and their applications" World scientific, 2018.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: I
Subject: Mathematics(Statistics)		
Course Code: B230707P	Course Title: Computation Lab-I	

Course outcomes:

1. To understand the basic concept of computer operation.
2. Able to learn, understand and apply to prepare the excel sheet for any given data.
3. Able to learn, understand and apply the technique of PPT for presentation of any data and subject.
4. Students will be able to apply internet technique to transfer any type of data.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-8

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Unit	Topics	No. of Lectures/ Practicals
I	MS Word : Creating, editing, saving and printing text documents, Font and paragraph formatting ,Simple character formatting, Inserting tables, smart art, page breaks , Using lists and styles, Working with images, Using Spelling and Grammar check, Understanding document properties, mail merge.	15
II	MS Excel: Spreadsheet basics, Creating, editing, saving and printing spreadsheets, Working with functions & formulas, modifying worksheets with colour & autoformats, Graphically representing data : charts & graphs, speeding data entry : using data forms , Analyzing data : data menu, subtotal, filtering data, formatting worksheets, securing & protecting spreadsheets.	15
III	Power Point Presentation: opening, viewing, creating, and printing slides, applying auto layouts, adding custom animation, using slide transitions, graphically representing data: charts & graphs, creating professional slide for presentation.	15
IV	Internet: understanding how to search/Google, bookmarking and going to a specific website, copy and paste Internet content into your word file and emails. understanding social media platforms such as Facebook & Many more, learn with best practices.	15

Suggested Readings:

1. Sinha P. and Pradeep, K., "Computer Fundamentals: Concepts, Systems & Applications", 8th Edition, BPB, 2004.
2. Treays, Rebecca, "Computers for Beginners" E.D.C. Publishing, 2002.
3. Agrawal, G. , "Learn Computer Basics", Ver II, Digital Muneem, 2017.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: II
Subject: Mathematics(Statistics)		
Course Code: B23801T	Course Title: Mathematical Methods	

Course outcomes:

1. To learn understand and apply the Fourier transform and its properties to evaluate the solution of heat, wave and Laplace equation.
2. To learn understand and apply Z-transforms and its properties to find the solution of difference equations.
3. To learn and understand the basic concepts of Integral Equations and its properties as kernel, Eigen values and Eigen functions of integral equations.

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4. To learn understand and apply basic concepts of calculus of Variations and to find the solution of geodesics and Rayleigh-Ritz differential equations.	
Credits:4	**Elective**
Max. Marks: 25+75	**Min. Passing Marks:40**
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Fourier transform, properties of fourier transform, inversion formula, convolution, parseval's identity, application of fourier transforms in solving heat, wave and laplace equation.	15
II	Z-transforms, relation of Z-transform with fourier transform, geometrical interpretation of Z-transform, region of convergence, inverse z-transform, convolution, solving difference equations by z-transforms.	15
III	Integral equations: integral equations of fredholm and volterra type, solution by successive substitution and successive approximation, integral equations with degenerate kernels. integral equations with symmetric kernel, eigen values and eigen functions of integral equations.	15
IV	calculus of variations: the extremum of functionals, variation of functional, euler equation in one and several independent variables, sufficient conditions for the extremum of a functional, variation problems with constraints, problem of geodesics and isoperimetric, RayLeigh-Ritz method of solving differential equations.	15

Suggested Readings:

1. Sneddon, I. N., "The Use of Integral Transforms", Mc Graw Hill, 1985.
2. Goldberg, R. R., " Fourier Transform". Cambridge University Press, 1970
3. Elsegolc, L., "Calculus of Variation", Dover Publications, 2010.
4. Kenwal, R. P., "Linear Integral Equation; Theory and Techniques", Academic Press, 1971.
5. Hildebrand, F. B., "Methods of Applied Mathematics", Dover Publications.

Pal, S. and Bhunia, S. C., "Engineering Mathematics", Oxford University Press, 2015.

Suggestive digital platforms web links

This course can be opted as an elective by the students of following subjects: M.Sc. (Physics, Electronics)

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in	Year: First	Semester: II

Mathematics (Statistics)		
Subject: Mathematics(Statistics)		
Course Code: B230802T	Course Title: Linear Algebra	

Course outcomes:

1. Able to understand the Applications of matrices in finding the solution of homogeneous system of equations and inverse of a matrix.
2. Able to apply cramer's rule to find the solution of system of equations and understand the concept of linear transformation of matrix, kernel, rank and nullity theorem.
3. Able to understand and apply characteristic polynomials to evaluate eigen values & eigen vectors. understand the concept of Cayley-Hamiltonian theorem and applications in finding inverse matrix and also diagonalization.
4. Able to understand the basic concept of Congruent symmetric matrices, Congruence Diagonalization, Quadratic forms and orthogonal matrices and their applications.

Credits:4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0

Unit	Topics	No. of Lectures
I	Vector space, subspaces, linear dependence, basis, dimension, Matrices: row reduced Echelon form, solution of system of linear equations and homogeneous system, inverse of a matrix (By using algorithm).	15
II	Determinants, Cramer's rule, vectors, inner product, C-S inequality, Metric in R, triangular inequality, Linear transformations and matrices, kernel, Nullity theorem, Rank of a matrix, Similarity.	15
III	Characteristic polynomials, eigen values, theorems on eigen values and eigen vectors. Cayley-Hamiltonian theorem. properties of characteristic polynomials, direct sum, Jordan form and diagonalization.	15
IV	Congruent symmetric matrices, law of inertia, congruence diagonalization of a symmetric matrix. change of variable matrix, change of variable and diagonalizing. quadratic forms, diagonalization alogrithms, positive definite symmetric matrices and quadratic forms, orthogonal matrices.	15

Suggested Readings:

1. Hoffman and Kunze, "Linear Algebra", PHI, 1978.
2. Rao, A.R, Bhimashankaram P., "Linear Algebra", Tata Mc-Graw Hill.
3. Kumareson, S., "Linear Algebra", PHI.
4. Rao & Bhimsankaran, "Linear algebra", Springer

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: II
Subject: Mathematics(Statistics)		
Course Code: B230803T	Course Title: Topology II	

Course outcomes:

1. To understand and illustrate Separation axioms and their basic properties, Metric spaces, compactness and its basic properties, Local compactness and one point compactification.
2. Demonstrate the knowledge of understanding Connected spaces, connectedness on the real line, Components, Locally connected spaces.
3. Understand and analyze Tychonoff product topology in terms of standard subbase and its characterization, compactness and product spaces (Tychonoff theorem), Countability and product spaces. Urysohn's metrization theorem.
4. Analyze and illustrate the concept of the fundamental group and covering spaces-homotopy of paths. The fundamental group, covering spaces, the fundamental group of circle and the fundamental theorem of algebra.

Credits:4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Separated sets, Connected set and Disconnected sets,Connected Topological spaces, Disconnected topological spaces, alternative definitions of connected and disconnected set, connectedness on the real line, Components, Locally connected spaces and arcwise connected sets.	15
II	Separation axioms: T_0 , T_1 and T_2- Space , Regular space and T_3 – spaces, Normal Spaces and T_4-spaces, Urysohn's lemma and Tietze extension theorem.	15
III	Separetion axions: completely normal sapces and T_5- spaces, completely regular sapces and $T_{3\frac{1}{2}}$- spaces, net and filters, topology and convergence of nets, Hausdorff spaces and nets, filters and their convergence, Ultra filters, canonical way of converting nets to filters and vice-versa.	15
IV	Prodeuct spaces: product topology, product of first countable spaces, second countable spaces, projections mappings, product of connected spaces and compact spaces, product of T_2-spaces, Tychonoff product topology in terms of standard subbase and its characterization, compactness and product spaces (Tychonoff theorem).	15

Suggested Readings:

1. Simmons, G.F., "Introduction to Topology and Modern Analysis", McGraw-Hill, 1963.
2. Kelly, J. L., "Topology", Van Nostrand Reinhold Co. New York, 1995.
3. Munkres, James R., "Topology, A first courses", Prentice Hall of India Pvt. Ltd. New Delhi,2000.
4. Dugundji, J., "Topology", Allyn & Bacon, (reprinted in India by Prentice Hall of India Pvt.

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Ltd., 1966.
5. Joshi, K. D. "Introduction to general Topology", Willey Eastern Ltd., 1983.
6. Hocking J. & Young G. "Topology", Addision-Wesley, Reading, 1961.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: II
Subject: Mathematics(Statistics)		
Course Code: B230804T	Course Title: Numerical Analysis	

Course outcomes:

1. Students will able to understand representation of integers and fractions, fixed point and floating point arithmetic, error propagation and able to compute method of error propagation.
2. They will able to learn how to evaluate polynomial Interpolation, error of the interpolating polynomial, oscillatory interpolation. They will also able to find out solutions of non-linear equations by different method.
3. They will able to calculate solution of linear algebraic equations and eigen value problems different methods (direct method, Iterative method).
4. They will able to calculate numerical integration by different rule and also are able to solve ODEs by different methods.

Credits:4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Numerical Computation: representation of integers and fractions, fixed point and floating point arithmetic, error propagation, loss of significance, condition and instability, computational method of error propagation.	15
II	Polynomial Interpolation: Existence and uniqueness of interpolation polynomial, Interpolation using differences, error of the interpolating polynomial, oscillatory interpolation, piecewise-polynomial approximation. Solution of nonlinear equations: Iterative methods, fixed point iteration, convergence of methods, polynomial equations, Miller's method, convergence acceleration.	15
III	Solution of linear algebraic equations and eigenvalue problems; Iteration method systems (Jacobi iteration method, Gauss seidel iteration method), convergence analysis, matrix factorization	15

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	methods (Doolittle's reduction, Crout reduction), Eigen value and Eigenvectors, Householder's method by symmetric matrices, Power method.	
IV	Numerical Integration: Basic rules of numerical integration (Newton's Cote's formula, Trapezoidal rule, Simpsons rule, Weddle's rule), Gaussian rules, composite rules, adaptive quadrature, limit, Romberg Integration. Solution of ODEs: Taylor series method, Euler's method and its convergence, Runge-Kutta methods, Multistep formulas, Predicator-Corrector methods, stability of numerical methods, numerical solutions of simultaneous ODE.	15

Suggested Readings:

1. Sastry, S. S., "Introductory methods of Numerical Analysis", PHI Learning Pvt., 2005.
2. Balaguruswamy, E, "Numerical Methods", Mac Milan.
3. Jain , Iyengar and Jain, "Numerical methods for Engineering and Scientists".
4. Conte, S. D. and de Boor C., "Elementary Numerical Analysis :An Algorithmic Approach", 3rd edn., McGraw Hill, 1981.
5. Henrici, P., "Elements of Numerical Analysis", John Wiley & Sons, 1964.
6. Froberg, C.E., "Numerical Mathematics, Theory and Computer Applications" the Benjamin Cummings Pub. Co. 1985.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: I
Subject: Mathematics(Statistics)		
Course Code: B230805T	Course Title: Applied Statistics	

Course outcomes:

1. Able to understand the basic concept of time series, components, trend and analysis of time series, various methods and uses of time series.
2. Able to understand basic concepts of index numbers, criteria and classification, cost and construction of living index numbers.
3. Able to understand simple random sampling, description of stratified random sampling & its optimum allocation formulae, large samples, small samples, hypothesis and testing of hypothesis by Z-test, t-test, F- test and χ^2 test.
4. Able to understand and apply the knowledge of analysis of variance and control charts ($\bar{X}$and R Charts, P Charts, NP Charts and C Charts) in real life problems.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0		
Unit	**Topics**	**No. of Lectures**
I	Definition and concept of time series, components of time Series, trend, periodic changes, irregular component, analysis of time series, uses of time Series, measurement of trend, graphic method, method of semi averages, moving average method, approximation to moving average.	15
II	Index numbers, problems involved in the construction of index numbers, the criteria of good index number, classification of index numbers, economic adviser's wholesale price index number, cost of living index number, main steps in the construction of cost of living index numbers, the construction of cost living index numbers.	15
III	Introduction, Simple random sampling, description of stratified random sampling & its optimum allocation formulae, sampling theory, small and large, hypothesis, null hypothesis, lternative hypothesis, testing of hypothesis, level of significance, confidence limits, test of significance of difference of means viz. Z-test, t-test, F-test and χ^2 test.	15
IV	Analysns of Variance (ANOVA), One way and two way classification, statistical quality control (SQC), control charts, control charts for attributes and variables ($\bar{X}$and R charts, P charts, NP charts and C charts).	15

Suggested Readings:

1. Gupta, S.C. and Kapur V.K., "Fundamentals of Applied Statistics", S. Chand & Sons, 1994.
2. Gupta, Goon and Gupta Das, " Fundamentals of Statistics" (Vol. II) & I, World Press,2016.
3. Sukhate and Sukhatme, "Sampling", The Indian Society of Agricultural Statistics, 1954.
4. Das M.N., and Giri N. C., "Design of experiments", Wiley Eastern Limited, New Delhi, 1979

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: I
Subject: Mathematics(Statistics)		
Course Code: B230806T	Course Title: Computing Fundamentals	

Course outcomes:

1. Able to understand the basic concept of Computer organization, number system, computer codes and arithmetic.
2. Able to understand basic concepts of Boolean algebra, Boolean functions, logic gates and circuits, algorithm and flow charting.

3. Able to understand Computer languages, machine language, high level language, compilers and characteristics of. 4. Able to understand and apply the knowledge of System implementation and operations, data processing, file organization, file utilities, data communication and networking.	
Credits:4	**Elective**
Max. Marks: 25+75	**Min. Passing Marks:40**
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Computer organization, number system, positional and non-positional, conversion from one system to another, computer codes and arithmetic.	15
II	Boolean algebra, Boolean functions, logic gates, logic circuits, planning the computer programmes, algorithm and flow charting.	15
III	Computer languages, analogy with natural languages, machine language and assembly language, high level language, compilers and interpreters, characteristics of good language , subroutines.	15
IV	System implementation and operations, operating systems, business data processing concepts, data processing and storage hierarchy, file organization, file utilities, sorting, sending and merging, database system, data communication and networking, transmission models.	15

Suggested Readings:

1. P K Sinha, Computer fundamentals, PBP Publication.
2. Br Eric D'Souza, Chipping-in SKW Software Ltd.

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the some basic knowledge of computer.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: First	Semester: II
Subject: Mathematics(Statistics)		
Course Code: B230807P	Course Title: Computing Lab-II	

Course outcomes:

1. Able to learn and understand the introduction of SPSS.
2. Able to learn and understand the basic statistical concepts.
3. Able to learn and understand about the statistical table and graph.
4. Able to apply SPSS to create frequency tables, cross table, bar chart, pie chart, Histogram.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-8

Unit	Topics	No. of Lectures/ Practical
I	Introduction, how to download and install SPSS, general functions, variable view, creating a new data set, data view, syntax, output.	15
II	Basic statistical concepts- measurements scales, distributions.	15
III	Descriptive statistics-tables, graphs, measures of central tendency, measures of variation.	15
IV	producing descriptive statistics in SPSS- descriptive, frequency tables, cross table, bar chart, pie chart, histogram.	15

Suggested Readings:

1. Jasrai Lokesh, "Data Analysis Using SPSS", SAGE Publications India Pvt Ltd; 1st edition, 2020.
2. Grotenhuis, Manfred te and Matthijssen Anneke, "Basic SPSS Tutorial", SAGE Publications, Inc; 1st edition, 2015.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: III
Subject: Mathematics(Statistics)		
Course Code: B230901T	Course Title: Complex Analysis	

Course outcomes:

1. Able to understand the significance of limit, continuity and differentiability for complex valued functions and be familiar with the Cauchy-Riemann equations.
2. Able to identify curves and regions in the complex plane defined by simple expressions.
3. Able to describe the basic properties of complex integration and having the ability to compute such integrals.
4. Able to decide when and where a function is analytic.
5. Able to compute Taylor and Laurent expansion of simple functions.
6. Able to understand the nature of singularities and calculating residues.
7. Able to use the Cauchy Residue theorem to evaluate integrals.
8. Able to describe conformal mappings between various plane and regions.

Credits:4	Core Compulsory

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Max. Marks: 25+75	Min. Passing Marks:40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Function of complex variable, continuity and differentiability, analytic functions, cauchy riemann equation (cartesian and polar form). harmonic functions, harmonic conjugate, construction of analytic functions. exponential stereographic projection and the spherical representation of the extended complex plane.	15
II	Complex line integral, Cauchy Goursat theorem, independence of path; Cauchy's integral formulas and their consequences, Cauchy inequality, Liouville's theorem, Fundamental theorem of algebra, Morera's theorem, maximum modulus principle, minimum modulus principle.	15
III	Circle of convergence, radius of convergence. Taylor's series and Taylor's theorem, Laurent's series and Laurent theorem, zeros and singularities of complex functions, classification of singularities: removable singularity, poles, essential singularities, Residue at a pole and at infinity, Cauchy's Residue theorem, Schwarz lemma, argument principle, Rouche's theorem.	18
IV	Conformal transformations, bilinear transformations, critical points, fixed points, problems on cross-ratio and bilinear transformation.	12

Suggested Readings:

1. Ahlfors, L.V., "Complex Analysis", 2nd Edition. McGraw-Hill International Student Edition, 1990.
2. Copson, E. T. "An Introduction to the Theory of functions of a complex Variable", Oxford university press, 1995.
3. Shastri, A. R., "An Introduction to Complex Analysis", Macmillan India Ltd., 2003.
4. Ponnusamy, S. and Silverman, H., "Complex Variables and Applications", Birhkäuser, 2006.
5. Churchill, R. and Brown , J. W., "Complex Variables and Applications", 6th Edition, McGraw-Hill, New- York, 1996.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: III
Subject: Mathematics(Statistics)		
Course Code: B230902T	Course Title: Operations Research	

Course outcomes:

1. Able to define LPP, formation of LPP and apply simplex methods to find the solution of LPP. Illustrate and understand the concept of duality in LPP.
2. Able to define and understand the transportation problem. By applying NWCR, LCM, VAM to find initial solution of TP. Further optimum solution by MODI method.
3. Illustrate the concept of non-linear programming, constraint optimization, unconstraint optimization and understand Kuhn-Tucker conditions, Kuhn-Tucker conditions for GNLPP with m (<n) constraints, sufficiency of Kuhn-Tucker conditions.
4. Able to define and understand concept of simulation, generate the random numbers by Monte-Carlo simulation and application of simulation.

Credits:4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Linear programming problem, introduction & concept, formulation of the problem, simplex method, basic & degenerates solution, fundamental properties of solutions (without proof), the computational procedure, the simplex algorithms use of artificial variables, two phase method, duality in LPP, introduction, general primal dual pair, standard primal & dual, formulas of dual, duality theorem-the dual of the dual is the primal, duality and simple method.	15
II	Transportation problem, introduction, general transportation problem, existence of feasible solution, basic feasible solution, transportation table, duality in transportation problem, loops in transportation table, solution of T.P.P., finding an initial basic feasible solution, North West Corner Rate (NWCR), Least cost method or matrix minima method, Vogel's approximation method, test for optimality, degeneracy, transportation method (MODI method), Assignment problem, formulation assignment method.	15
III	Non-linear programming introduction, formulation of non-linear programming problem, general non-linear programming problem (GNLPP), constrained optimization with equality constraints, necessary conditions for a general NLPP, sufficient conditions for a general NLPP with one constraint, sufficient conditions for a GNLPP with m (<n) constraints, constrained optimization with inequality constraints, sufficiency of Kuhn-Tucker conditions, Kuhn-Tucker conditions for GNLPP with m (<n) constraints, sufficiency of Kuhn-Tucker conditions.	15
IV	Simulation introduction, why simulation methodology of simulation, simulation models, event-type simulation, generation of random numbers Monte-Carlo simulation, steps of Mote-Carlo simulation, application of simulation.	15

Suggested Readings:

1. Swarup, K., Gupta, K. P. and Man Mohan, "Operations Research", Sultan chand & sons, New Delhi.
2. Kothari, C. R.., "An Introduction to O.R.", Vikas Publication house, New Delhi.
3. Sharma, J. K. "Operation Research, Theory and Applications", Mac Millan India Ltd. Delhi.
4. Taha, H. A., "Operational Research", Prentice Hall of India, 1997.

5. Bazarra, M. S., Sherali, H. D and Shetty, C. M. "Non-linear programming, Theory and Algorithm" New York Wiley.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: III
Subject: Mathematics(Statistics)		
Course Code: B230903T	Course Title: Functional Analysis	

Course outcomes:

1. Able to understand and illustrate the concept of continuous linear transformations, The Hahn Banach theorem.
2. To illustrate and apply The natural imbedding of N in N**, the open mapping theorem, the conjugate of an operator.
3. To understand and illustrate the basic concept of Hilbert Spaces along with some simple properties, Orthogonal complements, Orthogonal sets, The conjugate space H*, The adjoint of an operator.
4. To define and analyze self adjoint operators, Normal and Unitary operators, Projections, Finite dimensional spectral theory – spectrum of an operator, the spectral theorem.

Credits:4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0

Unit	Topics	No. of Lectures
I	Banach spaces: the definition and some examples, continuous linear transformations, the hahn banach theorem.	15
II	The natural imbedding of N in N**, the open mapping theorem, the closed theorem, uniform boundedness principle, the conjugate of an operator.	15
III	Hilbert Spaces–The definition and some simple properties, orthogonal complements, orthogonal sets, The conjugate space H*, The adjoint of an operator.	15
IV	Self adjoint operators, normal and unitary operators, Projections, finite dimensional spectral theory–spectrum of an operator, the spectral theorem.	15

Suggested Readings:

1. Siddiqui, A. H., "Functional Analysis with applications", TMG Publishing Co. Ltd, New

Delhi.
2. Jha, K. K., "Functional Analysis", Student's Friends,1986.
3. Taylor, A. E., "Functional Analysis", John wiley and Sons, New York,1958.
4. Kreyszig, E., "Introductory Functional Analysis with Applications", Wiley Eastern,1989.
5. Lahiri, B. K., "Elements of Functional Analysis", The world Press Pvt. Ltd., Kolkata, 1994.
6. Simmons, G. F., "Introduction to Topology and Modern Analysis", Mc-Graw-Hill, 1963.
7. Maddox, I. J., "Elements of Functional Analysis", University Book Stall, New Delhi.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	**Year: Second**	**Semester: III**
Subject: Mathematics(Statistics)		
Course Code: B230904T	**Course Title: Special Functions**	

Course outcomes:

1. Able to know basic concept of Hypergeometric Functions, Convergence Conditions, Absolute Convergence and its Properties also Gauss Theorem, quadratic transformations and Kummer's theorem.
2. Able to Generalized Hypergeometric Function in the proof of generalized hypergeometric function, binomial functions, The Confluent Hypergeometric Functions and properties also Kummer's first and second formula.
3. Able to learn understand and apply the Bessel Functions, Bessel Differential Equation and recurrence relations and generating function in various problems mathematical physics.
4. Able to learn understand and apply the Legendre's Polynomials, its generating function, recurrence relations, Rodrigue's differential formula also its orthogonality.

Credits:4	**Core Compulsory**
Max. Marks: 25+75	**Min. Passing Marks:40**
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	**Topics**	**No. of Lectures**
I	Hypergeometric functions ${}_2F_1$: preliminaries; definition, convergence conditions, absolute convergence, basic properties, the integral representation, F[a,b;c;1] as a function of the parameters; evaluation of F[a,b;c;1]; gauss theorem, simple transformations, relations between functions of z and 1-z, a quadratic transformation, other quadratic transformations, Kummer's theorem.	15
II	Generalized Hypergeometric Functions (${}_pF_q$): definition, convergence conditions (without proof); The exponential and	

	binomial functions; the integral representation, The ${}_pF_q$ with unit argument, Saalschutz's theorem, Dixon's theorem, The Confluent Hypergeometric Functions (${}_1F_1$) : basic properties, Kummer's first formula. Kummer's second formula.	15
III	Bessel functions: preliminaries, definition, bessel differential equation, differential recurrence relations, a pure recurrence relation, a generating function, Bessel's integral, index half and odd integer.	15
IV	Legendre's polynomials: definition, a generating function, differential recurrence relations, the pure recurrence relation, Legendre's differential equation, the Rodrigue's differential formula, bateman's generating, functions, hypergeometric forms of $P_n(x)$, Laplace's first integral form, some bounds on $P_n(x)$, orthogonality.	15

Suggested Readings:

1. Rainvill, E.D., "Special Functions", Macmillan Co., 1971.
2. Andrews, D.C., "Special functions of Mathematics for Engineers", Oxford Univ. Press, 1998.
3. Saran, N., Sharma, S.D. and Dwivedi, T.N., "Special Functions", Pragati Prakashan, Merrut.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: IV
Subject: Mathematics(Statistics)		
Course Code: B230905T	Course Title: Riemannian Manifolds	

Course outcomes:

1. Able to understand and apply Riemannian metrics, Conformal equivalence, and their properties.
2. To understand and apply Riemannian sub manifolds, Riemannian connection, Riemann curvature tensor. Sectional curvature. Ricci tensor, Ricci curvature, Scalar curvature. Real space forms.
3. To describe and apply arc length and energy of a piecewise smooth curve. Geodesics, Exponential map. Gauss Lemma and applications.
4. Able to understand and describe complete manifolds, Cartan-Hadamard Theorem, Cartan's Theorems (on determination of metric by curvature), Fundamental equations for Riemannian submanifolds and applications.

Credits: 4	Elective
Max. Marks: 25+75	Min. Passing Marks:40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Riemannian metrics, isometrics, conformal equivalence, examples including Euclidean n-space, spheres and hyperbolic spaces.	15
II	Riemannian sub manifolds, Riemannian connection, fundamental theorem of Riemannian geometry via Koszul's formula, Riemann curvature tensor, sectional curvature, Ricci tensor, Ricci curvature, scalar curvature, real space forms.	15
III	Arc length and energy of a piecewise smooth curve, first and second variation of are length and energy, geodesics, exponential map, Gauss lemma.	15
IV	Complete manifolds, Hopf-rinow theorem, Jacobi fields, Bonnet-Myers theorem, Cartan-Hadamard theorem, Cartan's theorems (on determination of metric by curvature), fundamental equations for Riemannian sub manifolds.	15

Suggested Readings:

1. Chern, S.S., Chen, W.H. and Lam K.S., "Lectures on Differential Geometry", World Scientific, 2000.
2. Carmo, MP do, "Riemannian Geometry", Birkhauser, 1992.
3. Hicks, N.J., "Notes on Differential Geometry", Von Nostrand, 1965.
4. Petersen, P., "Riemannian Geometry", Springer, 2006.
5. Jost, J., "Riemannian Geometry and Geometric Analysis", 6ed.Springer, 2011.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: III
Subject: Mathematics(Statistics)		
Course Code: B230906T	Course Title: General Relativity	

Course outcomes:

1. Students will learn tensor algebra and using it they will understand the general theory of relativity.
2. Students will apply general theory of relativity to various astrophysical systems like planetary motion, black holes and gravitational waves.
3. They will able to find out consequence of Einstein's theory compared to Newton's law of gravity.
4. Students will understand Gravitational field equations for non empty space, Energy – momentum tensor of perfect fluid, Schwarzschild internal solution.

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Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Tensor and their algebra, metric tensor, cristoffel symbols and their properties, covariant differentiation, riemannian geometry, curvature tensor: covariant curvature tensor, ricci tensor, einstein tensor, the bianchi identity.	15
II	Review of the special theory of relativity and the newtonian theory of gravitation, the principle of covariance, the principle of equivalence, geodesic principle, newton's equations of motion as an approximation of geodesic equations, poisson's equations as an approximation to einstein field equations.	15
III	Gravitational field equations in free space, exterior Schwarzchild's solution and its isotropic form, birkhoff's theorem, Schwarzchild singularity, planetary orbit, advance of perihelion of a planet, bending of light rays in the gravitational field, gravitational red shift in the spectral lines.	15
IV	Gravitational field equations for non empty space, Energy – momentum tensor of perfect fluid, Schwarzschild internal solution, Boundary conditions. energy momentum tensor of an electromagnetic field, Einstein-Maxwell equations, Interior Schwarzchild's solution.	15

Suggested Readings:

1. Adler, Ronald, Bezin, Maurice and Schiffer, Manamen, "Introduction to General Relativity", McGraw-Hill Kogakusha Ltd.
2. Rosser W.G.V., "Introduction to theory of relativity", ELBS (1972).
3. Rindler W., "Relativity Special, General and Cosmology", Pub. Oxford University Press (2003).
4. Landau I.D. and Lifshitz E.M., "The Classical Theory of Fields", Pub. Pergamon Press (1978).

Karade, T. M. and Khadekar, G. S., "General Theory of Relativity" Pub. SONU NILU

Suggestive digital platforms web links

This course can be opted as an elective by the students of following subjects: M.Sc.(Physics, Electronics)

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

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Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: III
Subject: Mathematics(Statistics)		
Course Code: B230907P	Course Title: Computing Application- Lab III	
Course outcomes:		
Credits:4	Elective	
Max. Marks: 25+75	Min. Passing Marks:40	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-8		

Unit	Topics	No. of Lectures/ Practicals
I	Introduction, How to Install and download of R, Fundamentals of R, Vectors and assignment, Control Statement, Function in R.	15
II	Matrices in R, Strings, Arrays in R, R Factors, Data Frames in R, Graphical procedures, packages, Data Visualization in R..	15
III	MATLAB: Introduction, How to Install and download of MATLAB, The basics of MATLAB, Classification of MATLAB system.	15
IV	MATLAB Computation: Matrices addition, Matrix Multiplication, Arrays, Function.	15

Suggested Readings:

1. Andankar, Praful V., Rafi, Shaik Mohammad, Ameta, Gaurav Kumar and Bhanushali, Mahesh Manoha , "R Programming for Beginners", Notion Press; 1st edition 2021.
2. Lander, Jared P., "R for Everyone: Advanced Analytics and Graphics", Pearson Education; Second edition, 2018.
3. Singh, Kulwinder and Bakariya Parmar Brijesh, "Fundamental Concepts of Matlab Programming" BPB Publications, 2020.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Class: Master in Mathematics (Statistics)	Year: Second	Semester: IV
Subject: Mathematics Program (Statistics)		
Course Code: B231001T	Course Title: Ordinary and Partial Differential Equations	

Course outcomes:

1. To learn understand and apply the methods of Ordinary Differential Equations in Mathematical Models, Existence of Uniqueness and continuity theorems, separation and

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comparison theorems.

2. To learn understand and to find the solution of Homogeneous and Non homogeneous Linear systems along with and beyond boundary conditions
3. To learn and understand First order PDE and apply it to find the solution Quasi-linear equations, Lagrange's method, compatible systems, Charpit's method.
4. To learn and understand the Jacobi's method also to evaluate the non linear partial differential equation by Monge's method.

Credits:4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0

Unit	Topics	No. of Lectures
I	Ordinary Differential Equations: First order equations, existence and uniqueness of solutions, linear systems, homogenous linear system with constant coefficients, nonlinear systems, Volterra's prey-predator equations. Nonlinear equations: Autonomous systems, the phase plane and its phenomena, critical point and stability for linear systems, simple critical points of nonlinear systems.	15
II	Oscillation theory and boundary value problems: qualitative properties of solutions, Sturm Comparison theorem, Sturm separation theorem, eigen values, eigen functions. Sturm Liouville Boundary value problem Two point boundary value problem: Introduction, The two homogeneous boundary problem, the adjoint boundary problem, the non-homogeneous boundary problem, self-adjoint boundary problem.	15
III	First order PDE and its solutions, classification and solutions, Pfaffian differential equations, Quasi-linear equations, Lagrange's method, classification and first order partial differential equation, integral surfaces passing through a curve, surfaces orthogonal to a given system of surfaces.	15
IV	Non linear partial differential equation of first order, Charpit's method, Compatible systems, Jacobi's method, Integral surfaces passing through a given curve, method of characteristics for quasi-linear and non-linear partial differential equation, Monge's method.	15

Suggested Readings:

1. Simmions, G. F., " Differential Equations" CRC Press (Taylor and Francis), USA
2. Ross, S. L., " Differential Equations" Wiley India Edition, New Delhi,
3. Sneddon, Ian N., "Elements of Partial Differential Equations", DOVER PUBLICATIONS, INC., 2006.
4. Rai Singhania, M. D., "Ordinary and Partial Differential equations", S. Chand Group, New Delhi.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses: .....
Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: IV
Subject: Mathematics(Statistics)		
Course Code: B231002T	Course Title: Advanced Operation Research	

Course outcomes:

1. Able to understand the basic concept of inventory effective factors, EOQ problems with and without shortages and EOQ problem with several unequal's lengths.
2. Able to understand and apply the deterministic inventory problems with instantaneous production, fixed order cycle and EOQ problems with one price break and probabilistic inventory models.
3. Define and illustrate the concept of queueing theory, performance measures, distribution of arrivals, distribution of inter arrivals time.
4. To know the concept of distribution of departure, distribution of service time, characteristics of waiting time distribution, Littles formula.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Inventory control: introduction, inventory decisions, costs associated with inventories, factors affecting inventory control, economic order quantity (EOQ), deterministic inventory problems with no storages: fundamental EOQ problem, EOQ problem with several production runs of unequal length.	15
II	deterministic inventory problem with shortages, EOQ problem with instantaneous production and variable order cycle time, EOQ problem with instantaneous production and fixed order cycle, EOQ problem with price break, EOQ problem with one price break, probabilistic inventory models.	15
III	Queueing theory, introduction, queueing system, elements of queueing system, input process, queue discipline, service mechanism, capacity of the system, operating characteristics of queueing system, probability distributions in queueing system, distribution of arrivals (pure birth process), distribution of inter-arrival times.	15
IV	Distribution of departures (pure death process), distribution of service times, classification of queering models, transient and steady states, poission queuing systems, model M/M/1: ∞/FIFO, derivation character this waiting time distribution derivation, characteristics of waiting time distribution, little's formula.	15

Suggested Readings:

1. Swarup, K., Gupta, K. P. and Man Mohan,, "Operations Research", Sultan Chand & Sons, N. Delhi.
2. Kothari, C. K.,"An Introduction Operations Research", Vikas publications House, New Delhi.

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3. Sharma, J. K., "Operations Research- Theory & Applications", Mac Million India Ltd, Delhi.
4. Taha H. A., "Operations Research", Prentice Hall of India .
5. Hillier F. S. and Lieberman G. J., "Introduction of Operations Research", Mc Graw Hill, New York.
6. Marlow W.H. Dover, "Mathematics for Operations Research", Now York.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: IV
Subject: Mathematics(Statistics)		
Course Code: B231003T	Course Title: Discrete Mathematics & Graph Theory	

Course outcomes:

1. To understand and illustrate the basic concept of semi groups & monoids, Homomorphism of semi groups and monoids. Congruence relation and quotient semi groups. Sub semi group and sub monoids. Direct products. Basic homomorphism theorem.
2. Demonstrate the knowledge of Lattices posets and their applications in societal problems.
3. To understand the concept of boolean algebra application in switching algebra, Various boolean identities, Boolean forms and their equivalence.
4. Able to understand and apply the concept of graph, cycles & sub graphs. Induced sub graphs. Degree of a vertex. Connectivity. Planar graphs and their properties. trees. Euler's formula for connected planar graphs.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Semigroups & monoids: definition and examples of semigroups and monoids, homomorphism of semigroups and monoids, congruence relation and quotient semigroups, subsemigroup and submonoids, direct products, basic homomorphism theorem.	15
II	Lattices: lattices as partially ordered sets. their properties. lattices as algebraic systems. sublattices. direct products and homomorphisms. some special lattices e.g. complete, complemented and distributive lattices.	15
III	Boolean algebras: boolean algebras as lattices, various boolean identities, the switching algebra example, subalgebras, direct products and homomorphisms, join-irreducible elements, atoms and	15

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	minterms, boolean forms and their euivalence.	
IV	graph theory: definition of graphs, paths, circuits, cycles & subgraphs, induced subgraphs, degree of a vertex, connectivity, planar graphs and their properties. trees, Euler's formula for connected planar graphs.	15

Suggested Readings:

1. Li, C. L. "Elements of Discrete Mathematics", (Second Edition), McGraw Hill, International Edition, Computer Science Series, 1986.
2. Tremblay J.P. and Mnohar,R., "Discrete Mathematical Structures with Applications to Computer Science", Mc Graw-Hill Book Co., 1997.
3. Deo Narsingh, "Graph Theory with Application to Engineering and Computer Sciences", Prentice Hall of India.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: IV
Subject: Mathematics(Statistics)		
Course Code: B231004T	Course Title: Demography	

Course outcomes:

1. To learn and understand the basic concepts of census for world and India.
2. To learn and understand and apply the basic concepts of source of demographic data, Scope and application of demography.
3. To Describe and apply the knowledge of measurement of mortality and life table and its applications.
4. To understand and apply the basic concepts of the concepts of theory of migration and its types.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0

Unit	Topics	No. of Lectures
I	Source of population Data World: Census, Registration of vital events, demographic surveys, population registers. India: Census, civil registration system (CRS), Sample registration Scheme (SRS), National sample survey(NSS), Demographic surveys and other sources.	15

II	Source of demographic data, scope and application of demography. content error in demographic data, balancing equations, Chandrasekharan-deming formula to check completeness of registration data, population composition and its measures. dependence ratio. Rates of population growth: arithmetic, geometric and exponential rates of growth; doubling time.	15
III	Demographic Methods: measurement of mortality and life table: crude, standardised and age-specific death rate, infant mortality rates, rate by cause, complete and abridged life table and its main features, uses of life table, measurement of fertility: crude birth rate, general fertility rate, age-specific birth rate, total fertility rate (TFR), gross reproduction rate (GRR) and net reproduction rate (NRR).	15
IV	Theory of migration, types and measures of migration, migration rates, volume of migration and its estimation, Lee's model, Zipf's model, Stowffer's model for the migration process, Hamilton's rate, migration component, migration streams. Reproductive health: concept of framework, reproductive morbidity; prevalence of RTI (reproductive tract infection) STS's and HIV/AIDS; estimate levels and interventions.	15

Suggested Readings:

1. Keyfitz, N., "Applied Mathematical Demography", John Wiley & Sons N.Y., 1977.
2. Cox P.R., "Demography", Cambridge University Press, 1976.
3. Spiegelman, M., "Introduction to Demography", Harvard University Press, 1980.
4. Ramakumar, R., "Technical Demography", Wiley Eastern limited, 1986.
5. Bhende A. and Tanitkar, Tara, "principle of population studies", Himalaya Publishing House Pvt. Ltd.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: IV
Subject: Mathematics(Statistics)		
Course Code: B231005T	Course Title: Advanced Special Functions	

Course outcomes:

1. Able to learn understand Hermite Polynomials, Recurrence relations, generating functions, orthogonality and some special problems and may apply in various physical problems.
2. Able to understand and describe Jacobi polynomials, Bateman's generating function,

Rodrigue's formula, orthogonality, and mixed relations and may study their generalization

3. Able to understand, describe and apply the concept of gagenbauer polynomials ,Explicit representation, generating function and its orthogonality.
4. Able to understand, describe and apply the concept of ultraspherical polynomials, Basic properties, Tchebicheff polynomials and its properties, Certain generating function and may consider their generalization and applications.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0

Unit	Topics	No. of Lectures
I	Hermite polynomials $h_n(x)$: definition, recurrence relations, the Rodrigue's formula, other generating functions, integrals, the hermite polynomial as a ${}_2F_0$, orthogonality expansion of polynomials, more generating functions, laguerre polynomials $L_n^{\alpha}(x)$: definition, generating functions, recurrence relations, the Rodrigue's formula, the differential equation, orthogonality, expansion of polynomials, special properties, other generating functions.	15
II	Jacobi polynomials, $P_n^{(\alpha,\beta)}(x)$: definition, Bateman's generating function, the Rodrigue's formula, orthogonality, differential recurrence relations, the pure recurrence relation, mixed relations.	15
III	Gagenbauer polynomials: definitions, simple set of polynomials, explicit representation, generating function, differential recurrence relations, Bateman's generating relation, orthogonality,	15
IV	The ultraspherical polynomials : definition, certain basic properties, relation with gagenbauer polynomials. tchebicheff polynomials: definition, basic properties, explicit formula, certain generating function.	15

Suggested Readings:

1. Rainvill, E.D., "Special Functions", Macmillan Co., 1971.
2. Andrews, D.C., "Special functions of Mathematics for Engineers", Oxford Univ. Press, 1998.
3. Saran, N., Sharma, S.D. and Dwivedi, T.N., "Special Functions", Pragati Prakashan, Merrut.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: IV
Subject: Mathematics(Statistics)		

Course Code: B231006T	Course Title: Finsler Geometry

Course outcomes:

1. Understand the basic of this course and think & develop new ideas in this course.
2. Know Finsler metric function, Dual tangent space, Geodesics, Fundamental postulates of Cartan, Berwald's covariant derivative and its properties, Commutation formula resulting from partial δ-differentiation, Three curvature tensors of Cartan.
3. Cover a wide area of research in differential geometry & Finsler Geometry.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0

Unit	Topics	No. of Lectures
I	Finsler metric function and its properties, tangent space, indicatrix. metric tensor and c-tensor homogeneity properties of g_{ij} and c_{ijk}.	15
II	Dual tangent space, geodesics, δ-differentiation, partial δ-differentiation, properties of partial δ differentiation.	15
III	Fundamental postulates of Cartan, Cartan's covariant derivatives and their properties, geometry of paths, Berwald's covariant derivative and its properties.	15
IV	Commutation formula resulting from partial δ-differentiation, other commutation formulae, three curvature tensors of Cartan, identities satisfied by curvature tensors including bianchi identities.	15

Suggested Readings:

1. Rund, H., "The Differential Geometry of Finsler Spaces", Springer-Verlag, 1959.
2. Matsumoto, M., "Foundations of Finsler Geometry and special Finsler spaces", Kaiseisha Press, Saikawa, Otsu, 520 Japan, 1986.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.

Suggested equivalent online courses:

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Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: IV

Subject: Mathematics(Statistics)

Course Code: B231007T	Course Title: Cosmology

Course outcomes:

1. Students will understand models of expanding Universe in connection with the general theory of relativity.
2. They will understand Mach principle, Einstein modified field equations with cosmological term, Static cosmological models of Einstein and de Sitter and their derivation and its properties.

3. They will understand Friedman Model, Fundamental equation of dynamical cosmology, density and pressure of the present universe. They will be introduced to concepts of exotic components of matter in the Universe like dark matter and dark energy. 4. They will be introduce Steady state cosmology, Distance measure in cosmology, Comoving distance, Apparent luminosity and luminosity distance.	
Credits:4	**Elective**
Max. Marks: 25+75	**Min. Passing Marks:40**
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Mach principle, Einstein modified field equations with cosmological term, static cosmological models of Einstein and de sitter and their derivation and its properties: (i) the geometry of the universe (ii) density and pressure (iii) motion of test particle (iv) doppler shift (v) comparison with actual universe, comparison between Einstein and de-sitter models.	15
II	Hubble law, cosmological principle, Weyl's postulate, derivation of robertson walker metric and its properties, motion of a particle and light rays in FRW model, red shift, deceleration parameter and hubble's parameter, matter dominated era.	15
III	Friedman model, fundamental equation of dynamical cosmology, density and pressure of the present universe, matter dominated era of the universe, critical density, flat, closed and open universe, age of the universe.	15
IV	Steady state cosmology, distance measure in cosmology, commoving distance, apparent luminosity and luminosity distance, angular diameter and lookback time, galaxy count.	15

Suggested Readings:

1. Tolman, Richard C., " Relativity, Thermodynamics and Cosmology ", Oxford Press.
2. Weinberg , Steven, "Gravitation and Cosmology : Principles and Applications of the General Theory of Relativity" .
3. Karade, T. M. and Khadekar, G. S., "General Theory of Relativity", Pub. SONU NILU.
4. Roy, S. R. and Bali, Raj, "Theory of Relativity", Jaipur Publishing House, Jaipur, 1987.
5. Rosser, W.G.V., "Introduction to theory of relativity", ELBS, 1972.
6. Stephani, H., "Genereal Relativity: An Introduction of the theory of the gravitational field", CambridgeUniversity Press, 1982.
7. Eddington, A. S., "The Mathematical Theory of Relativity", CambridgeUniversity, Press, 1965.
8. Narlikar, J.V., "General Relativity, and Cosmology", The Macmillan Company of India Ltd., 1978.
9. Adler, R., Bazin M. and Schiffer, M., "Introduction to General Relativity", McGraw Hill Inc., 1975.
10. Shutz, B. F., "A first course in general relativity", Cambridge University Press, 1990.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:

Total Marks: 25
House Examination/Test: 10 Marks
Written Assignment/Presentation/Seminar: 10 Marks
Punctuality/Active Participation: 5 Marks

Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.
Suggested equivalent online courses: .....
Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Program/Class: Master in Mathematics (Statistics)	Year: Second	Semester: IV
Subject: Mathematics(Statistics)		
Course Code: B231008T	Course Title: Advanced Statistical Inference	

Course outcomes:

1. Able to learn and understand estimation, Factorization criterion and its applications.
2. Able to understand and apply Rao-Blackwell theorem, completeness and bounded completeness, Lehman-Sheffe theorem, Cramer-Rao bound and its generalization the basic statistical concepts.
3. Able to learn, understand and apply the existence theorem in real life problems.
4. Able to learn and understand testing of hypothesis and critical region and power full test and apply it through Pearson lemma, Generalized N-P Lemma.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-1-0	

Unit	Topics	No. of Lectures
I	Estimation, point estimation, unbiasedness, consistency, efficiency and sufficiency of estimators. factorization criterion, maximum likelihood method of estimation, method of moments, interval estimation.	15
II	Rao-Blackwell theorem, completeness and bounded completeness, Lehman-Sheffe theorem, Cramer-Rao bound and its generalization.	15
III	existence of UMVUE estimator, its necessary and sufficient conditions, minimum variance bound estimators, exponential family of distributions and sufficiency.	15
IV	Testing of hypotheses, critical region and most powerful test, Neyman Pearson lemma, generalized N-P lemma, likelihood ratio principle, their asymptotic properties and its simple applications.	15

Suggested Readings:

1. Bhattacharya, D.,"Probability And Statistical Inference Theory And Practice", U. N. Dhur and Sons Private Limited; 3rd edition, 2019
2. *George Casella and Roger L., "Statistical Inference" second edition, Duxbury Advanced Series publication, 2007.*
3. Goon, A.; Gupta, M. and Das, F. A., "An Outline of Statistical Theory" Vol. II, World Press, 2013.
4. V.K. Rohatgi: Probability and Mathematical Statistics, John Wiley & sons, 2015.

Suggestive digital platforms web links

Suggested Continuous Evaluation Methods:
Total Marks: 25 House Examination/Test: 10 Marks

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Written Assignment/Presentation/Seminar: 10 Marks Punctuality/Active Participation: 5 Marks
Course prerequisites: To study this course, a student must have the mathematics/statistics in B.Sc.
Suggested equivalent online courses: .....
Further Suggestions: None

At the End of the whole syllabus any remarks/ suggestions: None

Note:

- The students have to opt **Five** of the elective course in Fourth semester.
- Regulation (Ordinance) of concerned program will remain same as previous one.

Ordinance (Regulation) Governing The Programme
M.Sc. Mathematics (Statistics)
Department of Mathematics & Statistics
Faculty of Science
Dr. Rammanohar Lohia Avadh University Ayodhya (U.P.)

Course Structure of M.Sc. Mathematics (Statistics) for the Department of Mathematics and Statistics under NEP-2020

Name of the Department: The name of the department is "Department of Mathematics and Statistics" which provides M.Sc. and Ph.D. degree in mathematics and its related thrust area.

Name of the degree: The department provides degree of Master of Science in Mathematics (Statistics). It stands for degree of M.Sc. in Mathematics with Specialization in Statistics. This degree is equivalent to the M.Sc. degree in Mathematics. Apart from this, department also provides the Ph.D. degree in mathematics related thrust area.

Venue of the Programme: Department of Mathematics and Statistics, Dr. Rammanohar Lohia Avadh University, Ayodhya-224001, UP, India

Eligibility of the M. Sc. Programme: B.Sc. Mathematics/Statistics with minimum 45% marks in aggregate.

Admission Process: For all categories of the students, it shall be through merit of qualifying exam or entrance's merit as per university system/instruction from time to time.

Semester wise Course Structure: M.Sc. Mathematics (Statistics)

Two year regular programme (effective from session 2022-2023)

The M.Sc. Mathematics (Statistics) examination will consist of four semesters, called first, second, third and fourth semester. Their examination will be held in the month of December/January and April /May respectively in each year. In each of this semester-examination, there will be five theory papers and one practical paper /project/ seminar presentation. Each paper will carry 100 marks and of three hours duration having two components: internal assessment of 25 marks and end-semester examination (external component) will be of 75 marks. For practical/project marks will carry 100 marks also and it has two components: internal assessment of 50 marks and external assessment will be of 50 marks. Semester wise course structure is given below:

Course Code		Course Title	Credits	T/P	Evaluation	
					CIE	ETE
A	B	C	D	E	F	G
SEMESTER I (YEAR I)						
B230701T	CORE	Real Analysis	4	T	25	75
B230702T	CORE	Advanced Abstract Algebra	4	T	25	75
B230703T	CORE	Topology-I	4	T	25	75
B230704T	CORE	Differential Geometry of Manifold	4	T	25	75
B230705T	FIRST ELECTIVE (Subject Elective) (Select any one)	Probability and Statistical Methods	4	T	25	75
B230706T		Fuzzy Theory and Its Applications	4	T	25	75
B230707P	SECOND ELECTIVE (Subject Elective) (Select any one)	Computing Lab-I	5	P	50	50
B230708P		Project/Seminar Presentation	5	P	50	50
SEMESTER II (YEAR I)						
B230801T	CORE	Mathematical Methods	4	T	25	75
B230802T	CORE	Linear Algebra	4	T	25	75
B230803T	CORE	Topology-II	4	T	25	75
B230804T	CORE	Numerical Analysis	4	T	25	75
B230805T	THIRD ELECTIVE (Generic Elective) (Select any one)	Applied Statistics	4	T	25	75
B230806T		Computing Fundamentals	4	T	25	75
B230807P	FOURTH ELECTIVE (Subject Elective) (Select any one)	Computing Lab II	5	P	50	50
B230808P		Project/ Seminar Presentation	5	P	50	50

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SEMESTER III (YEAR II)						
B230901T	CORE	Complex Analysis	4	T	25	75
B230902T	CORE	Operations Research	4	T	25	75
B230903T	CORE	Functional Analysis	4	T	25	75
B230904T	CORE	Special Functions	4	T	25	75
B230905T	FIFTH ELECTIVE (Subject Elective) (Select any one)	Riemannian Manifold	4	T	25	75
B230906T		General Relativity	4	T	25	75
B230907P	SIXTH ELECTIVE (Subject Elective) (Select any one)	Computing Lab III	5	P	50	50
B230908P		Project/Seminar Presentation	5	P	50	50
SEMESTER IV (YEAR II)						
B231001T	CORE	Ordinary and Partial Differential Equations	4	T	25	75
B231002T	CORE	Advanced Operations Research	4	T	25	75
B231003T	SEVENTH ELECTIVE (Subject Elective) (Select any one)	Graph Theory and Discrete Mathematics	4	T	25	75
B231004T		Demography	4	T	25	75
B231005T	EIGTH ELECTIVE (Subject Elective) (Select any one)	Advanced Special Functions	4	T	25	75
B231006T		Finsler Geometry	4	T	25	75
B231007T	NINETH ELECTIVE (Subject Elective) (Select any one)	Cosmology	4	T	25	75
B231008T		Advanced Statistical Inference	4	T	25	75
B231009P	RESEARCH PROJECT/ DISSERTATION	Research Project	5	P	50	50

Evaluation of Theory Paper

Internal assessment of theory paper will be based on classroom participation, seminar and term test which is known as **continuous internal evaluation (CIE)** is of 25 marks. In each theory paper End Semester examination will carry 75 marks which is known as **external evaluation (ETE).**

Evaluation of Practical Paper

Internal assessment of practical paper will be of 50 marks based on lab participation/ record, seminar, test on practical and viva (lab participation/record-20 marks, test on practical-20 marks and viva-10 marks).

In practical paper, end –semester practical exam of 50 marks shall be in two components. First component will be of lab/written exam of 30 marks and second components will be of viva for 10 marks and attendance/ records for 10 marks. Evaluation of this exam will be done jointly by one internal and one external examiner as well.

Evaluation of Project Paper

Students of the IVth semester will be distributed amongst the faculty members of the department as advisors. Respective advisors will help identify the topic of the project according to interest of students. The topics and names of advisors will be placed in the departmental committee for final approval. In project work, a small group of students of the semester in which project is recommended as paper will be associated with one teacher of the department as advisor for the project. This allocation of advisors will be done by departmental committee of the department.

Internal assessment of project paper, which is of 50 marks, will be based on class room participation/discussion. Seminar and test on project (class room participation/discussion-10 marks, seminar-20 marks and test on project-20 marks).

In the project paper, end–semester project exam of 50 marks will be of two components. First component will be based on its evaluation of project of 30 marks and second components will be of viva for 10 marks and attendance/ records for 10 marks. Evaluation of this exam will be done jointly by one internal and one external examiner as well.

Passing Marks

Passing marks criteria for the students shall be considered as an aggregate 40% (including CIE & ETE) in each subject. Students concerned will be promoted to the nest semester according to the rules of back papers-exam laid down by the university itself. If any set of rules regarding passing marks of the students of M.Sc. programme is laid down by the university as common rules, then this common rule will supersede departmental rules regarding passing marks.

07/12/22

07/12/2022

R.S.Sunil (online present)