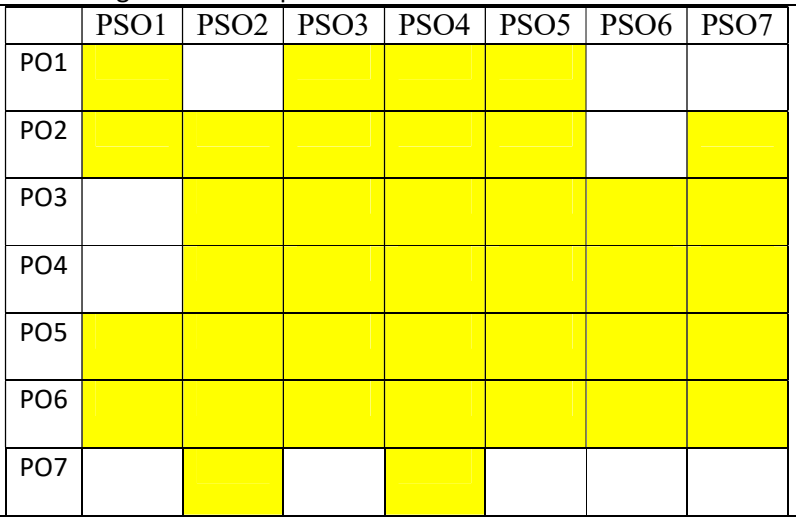
Master in Science (Statistics)

Name of Program	Master in Science Statistics
Abbreviation	M. Sc. Statistics
Duration	2 years
Eligibility Criteria	A candidate must have passed the Bachelor's Degree examination in Science with English as compulsory subject. A candidate shall have cleared B.Sc. Degree examination, provided, a candidate who has obtained his/her B.Sc. Degree with either (i) Statistics as principal subject or (ii) Mathematics as principal subject and Statistics as subsidiary subject or (iii) both Mathematics and Statistics as optional subjects, shall be considered eligible for admission to M.Sc. Degree course in Statistics.
Objective of Program	The core objective of the program is to prepare the students to be capable of doing any kind and every kind of data analysis and to be helpful to the society and academia by providing an outstanding environment of teaching and research in the core and emerging areas of the discipline.
Program Outcome	**PO1 : Fundamental Knowledge Enrichment** Program trains students with the core statistics knowledge. It also makes students capable of using core concepts in the conceptualization of domain specific application development. **PO2 : Critical Thinking Development** The program develops the skills of critical thinking, problem solving, evaluative learning of various techniques, and understanding the essence of the problem. **PO3 : Advanced Emerging Technology Awareness** The program trains students with the latest technologies that are being used in the industry/ research. The continuous syllabi review adds value to the program for the outgoing students and make them ready to face challenging demands of the industry. **PO4 : Advanced Tools Usage** The program teaches the students to apply the advanced tools to solve real world problems. **PO5 : Nurturing Project Planning and Management Capabilities** The program trains students for designing and conceptualizing the statistical techniques and software architecture, planning and managing the process of complex real life problems in statistical frame work. It also makes students understand the decision making for an appropriate technique selection capability. **PO6 : Real World Problem / Project Development** Real world project provides the candidates exposure to work in the challenging and demanding environment of the industry/research. The project development training makes students employable and industry ready. **PO7 : Team Work and Leadership Development** Trains students to work in a team and also to take leadership of the of the project management team.

Program Specific Outcomes	PSO1 : Develop and strengthen the fundamental core concepts that are required to solve complex problems PSO2 : Develop the professional and entrepreneurship skills that needs independent logical and analytical thinking, teamwork and leadership Construct rigorous mathematical proofs of basic results in real analysis. PSO3 : Nurture the students to investigate for the design and development of a workable solution for a real world problem PSO4 : Train students for self-learning and practicing challenging problem solution PSO5: Train students to apply statistical skills to analyze and interpret output for applications/solution of statistical analysis of real life problems. PSO6 : Train students to use recent techniques and software/programmes for application domain specific knowledge PSO7 : Inculcate the passion for continuous learning and doing research for making a successful professional career
Mapping between POs and PSOs	
Medium of Instruction	English

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Program Structure – Semester I								
Course Code	Title	Teaching per week		Course Credits	University Examination		Internal Marks	Total Marks
		Theory	Practical		Duration	Marks		
101	Real Analysis	4	-	4	3 Hrs	70	30	100
102	Probability Theory	4	-	4	3 Hrs	70	30	100
103	Univariate Distributions	4	2	4	3 Hrs	70	30	100
104	Linear Algebra	4	3	4	3 Hrs	70	30	100
105	Computer Programming Language - "C"	4	3	4	3 Hrs	70	30	100
106	Practical paper-I (Practical +viva- voce)based on theorypapers using MS office tools	-	-	4	3 Hrs	70	30	100

	Total	20	8	24				

Program Structure – Semester II								
Course Code	Title	Teaching per week		Course Credits	University Examination		Internal Marks	Total Marks
		Theory	Practical		Duration	Marks		
201	Estimation Theory	4	2	4	3 Hrs	70	30	100
202	Multivariate Analysis	4	2	4	3 Hrs	70	30	100
203	Sampling Theory	4	2	4	3 Hrs	70	30	100
204	Actuarial Statistics	4	2	4	3 Hrs	70	30	100
205	Linear Models	4	-	4	3 Hrs	70	30	100
206	Practical paper-II (Practical +viva-voce)based on theorypapers using MS office tools	-	-	4	3 Hrs	70	30	100
	Total	20	8	24				

Program Structure – Semester III								
Course Code	Title	Teaching per week		Course Credits	University Examination		Internal Marks	Total Marks
		Theory	Practical		Duration	Marks		
301	Testing of Hypothesis	4	2	4	3 Hrs	70	30	100
302	Econometrics	4	2	4	3 Hrs	70	30	100
303	Operations Research – I	4	1	4	3 Hrs	70	30	100
304	Introduction to Statistical Softwares	4	1	4	3 Hrs	70	30	100
3051 3052 3053 3054	Elective* (Any one) Data Mining Stochastic Processes Mathematical Economics Statistical Quality Control & Reliability	4	2	4	3 Hrs	70	30	100
306	Practical paper- III	-	-	4	3 Hrs	70	30	100

	(Practical +viva-voce) based on theory papers– using statisticalsoftware							
	Total	20	8	24				
*Elective Paper is to be selected from the above list of papers from paper 3051 to 3054								

Program Structure – Semester IV								
Course Code	Title	Teaching per week		Course Credits	University Examination		Internal Marks	Total Marks
		Theory	Practical		Duration	Marks		
401	Decision Theory	4	2	4	3 Hrs	70	30	100
402	Design of Experiments	4	2	4	3 Hrs	70	30	100
403	Operations Research-II	4	2	4	3 Hrs	70	30	100
	Elective* (Any one)	4	2	4	3 Hrs	70	30	100
4041	Economics & Business Statistics							
4042	Official Statistics							
4043	Bio-Statistics & Clinical Research							
4044	Statistical Simulation							
405	Practical paper-IV (Practical +viva-voce) based on theory papers– using statisticalsoftware	-	-	4	3 Hrs	70	30	100
Project**	At Some industry / firm/organization	4 hour per week per group		4		70	30	100
	Total	16	8	24		420	180	600
		24+ project workload						
*Elective Paper is to be selected from the above list of papers from paper 4041 to 4044 ** To be done at some industry / firm / organization.								

M. Sc. Statistics 1st Semester

Course-101: Real Analysis

<table>
<tr><td>Course Code</td><td>101</td></tr>
<tr><td>Course Title</td><td>Real Analysis</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>1970</td></tr>
<tr><td>Purpose of Course</td><td>The aim of the Course is to introduce fundamental Concept of real analysis such as the Concept of field, sigma field etc. hence to provide mathematical foundation for statistics Courses.</td></tr>
<tr><td>Course Objective</td><td>The purpose of this course is to make students acquainted with concepts of real analysis which is base of probability theory paper.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, the students will be able to:

CO1: Describe fundamental properties of the real numbers, sets, classes, function, inverse function, simple and measurable functions, distribution functions, measures etc. that lead to the formal development of real analysis/ probability theory.

CO2: Comprehend rigorous arguments developing the theory underpinning real analysis and base to probability theory.

CO3: Demonstrate and understanding of limits of sequences, series etc. Construct rigorous mathematical proofs of basic results in real analysis.
CO4: Students will be aware of the need and use of Real Analysis.
CO5: Concept of measure, its properties, and important results related to measure & their proofs and Construction of Lebesgue measure and Lebesgue Stiltjes measure.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><th></th><th>PSO 1</th><th>PSO 2</th><th>PSO 3</th><th>PSO 4</th><th>PSO 5</th><th>PSO 6</th><th>PSO 7</th></tr>
<tr><td>CO 1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO 2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO 3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO 4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</table>

	CO 5
Pre-requisite	Basics of set theory, limits of sequences and series, functions and limits of sequence of functions
Course Content	**UNIT I:** ➢ **Set, Indicator factions and classes of sets**: ➢ Recap of elements of set theory and Real number system. ➢ Limits of sequences of sets, ➢ Classes of sets like Semi-rings, rings, fields, σ -rings, σ -fields, Monotone classes. ➢ Generated classes, Borel σ -field of R and Rk and related results. **UNIT: II:** ➢ **Measurable Space:** ➢ Measurable space, simple function, Measurable function, Borel measurable function and related results. ➢ Almost everywhere convergence of sequence of measurable functions and related results. **UNIT: III:** ➢ **Set function and Measures:** ➢ Finitely additive and σ -additive set functions, ➢ Measures & its properties ➢ Monotone convergence theorem, ➢ Absolute continuity and singularity of measures. ➢ Statements of 'Lebesgue Decomposition theorem' and the Radon – Nikodym theorem. **UNIT: IV:** ● Integration of Simple functions and measurable function ➢ Integration of Simple functions with respect to a given measure & its properties ➢ Integration of measurable function with respect to a given measure. ➢ Elementary properties of integral of measurable function and related results. **UNIT: V:** ● **Caratheodory extension theorem & its Applications:** ➢ Caratheodory extension theorem (statement only) ➢ Construction of Lebesgue measures ➢ Lebesgue- Stieltjes measures through distribution functions.
Reference Books	1. Ash Robert : "Real Analysis and Probability"; Academic Press. 2. Halmos P.R. : "Measure Theory"; McGraw Hill.

	3. Kingman JFC and Taylor S.J. : "Introduction to Measure and Probability"; Cambridge Uni. Press. 4. Burrill C.W. : "Measure, Integration and Probability".
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 1st Semester

Course-102: Probability Theory

Course Code	102
Course Title	Probability Theory
Credit	4
Teaching per Week	4
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	1970
Purpose of Course	This course is the foundation for all other statistical inferential courses to be taught during different semester of the programme.
Course Objective	This will explain the concepts of probability space, probability measure. - Various inequalities. - Understanding stochastic independence of events, conditional expectations, use and need of characteristic functions and its properties, Law of Large Numbers, Central Limit theorems etc. with their applications. To make students acquainted with conceptsofprobability Theory and its applications.
Course Outcomes	CO1: The aim of the course is to pay a special attention to applications of Real Analysis in the foundation of probability theory CO2: Students learn to identify the characteristics of different discrete and continuous variables. CO3: The knowledge to define the type of variables for different situation to which different concepts of probability theory can be applied. CO4 :Understanding of the concept of expectation and conditional expectation and their real life applications CO5:Students learn to develop and apply different moment inequalities for statistical inference purpose CO6: Gain the ability to understand the concepts of random variable, sequence of random variables, convergence, modes of convergences. CO7: understanding of Weak Law of Large Numbers, Strong Law of Large Numbers and the Central Limit Theorem with their applications e.g. large-sample approximations for common statistics

Mapping between COs with PSOs	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1							
CO2							
CO3							
CO4							
CO5							
CO6							
CO7							

Pre-requisite	Different Concepts and results of Real Analysis
Course Content	**UNIT I:** • **Probability measure, random variable and inequalities:** ➢ Probability spaces, Random variables and random vectors. Expectations. Moments. ➢ Holder's inequality, Minkowski's inequality, Cauchy–Schwartz inequality, Markov's inequality, Jenson's inequality, Chebychev's inequality **UNIT II:** • **Distribution of a random variable and Characteristic functions:** ➢ Distribution function, joint distribution function. Decomposition of a d.f. in its discrete, absolutely continuous and singular parts. ➢ Weak convergence of sequences of distribution functions. The weak compactness theorem. ➢ Characteristic functions and their properties. ➢ Inversion theorem, Uniqueness theorem, Continuity theorem (statement only) and their properties. **UNIT III:** • **Stochastic Independence and Conditional Expectations:** ➢ Independence of events, classes and random variables. ➢ The multiplication theorem, Borel - Cantelli lemma, Borel zero-one law ➢ Sequence of independent random variables, Tail σ -field and Kolmogorov zero-one law. ➢ Conditional Expectations and its properties **UNIT IV:** • **Convergence of sequences of random variables:** ➢ Convergence almost everywhere of sequences of random variables in probability ➢ Convergence of sequences of random variables in rth mean and ➢ Convergence of sequences of random variables in probability ➢ Convergence of sequences of random variables in distribution ➢ Inter – relationships amongst these modes of convergence. **UNIT V:** • **Laws of Large Numbers and Central limit theorems:** ➢ Weak law of Large numbers,

	➢ Kolmogorov's inequality, Kolmogorov's strong law of large numbers. ➢ Central limit theorems- Liapunov's theorem. Statement of Lindbergh- Feller theorem.
Reference Books	1. LoeveM. : "Probability Theory". 2. Burrill C.W. : "Measure, Integration and Probability". 3. Ash Robert : "Real Analysis and Probability"; Academic Press. 4. Chang K.L.: "A Course in Probability Theory". 5. Dudley R.M. : "Real Analysis and Probability"; Wadsworth & Brooks.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 1st Semester

Course-103: Univariate Distributions

Course Code	102
Course Title	Univariate Distributions
Credit	4
Teaching per Week	4
Minimum weeks per Semester	15 (Including Class work, examination, preparation, holidays etc.)
Effective From	2019-20
Purpose of Course	The purpose of this course is to expose the students to different aspects of distribution theory and construction of these distributions.
Course Objective	To present the general theory of statistical distributions as well as the standard distributions found in statistical practice. To train students with essential tools for statistical analyses at the post graduate level.
Course Outcomes	After successful completion of this course, student will be able to: CO1: Understand the most common discrete and continuous probability distributions and their real-life applications. CO2: Calculate moments, quartiles and characteristic function from distributions CO3: Get familiar with different transformation of univariate distribution CO4: Apply compound, contagious, Neyman type-A and Truncated distributions to solve problems CO5: Become aware about power series distributions CO6: Differentiate between central and non-central distributions CO7: Learn how to model product failure, droughts, floods and other extreme occurrences on studying the theory of order statistics
Mapping between COs with PSOs	
Pre-requisite	Basics of probability distributions as Binomial, Poisson, Normal, Beta-Gamma etc.
Course Content	**UNIT I:** • Laplace, Lognormal and Cauchy distributions. Idea of truncated distributions, Truncated Poisson and Normal distributions. **UNIT II:** • Univariate compound distribution: Contagious distributions: Neyman type-A, Poisson-Binomial and Poisson –Negative Binomial distribution, Univariate Power series distributions.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■			■		■	
CO2	■			■			
CO3				■			
CO4	■		■	■	■		
CO5							
CO6	■						
CO7	■	■	■	■	■	■	

	UNIT III: • Non-central distributions: Non-central chi-square, t and F distribution. **UNIT IV:** • Ordered statistics, their distributions and properties, distribution of Range.
Reference Books	1. Johnson N.L. and Kotz S.: "Distributions in Statistics"; John Wiley. 2. Fioz M.: "Probability Theory and Mathematical Statistics"; John Wiley. 3. Rohatgi V.K. : "An Introduction to Probability Theory and Mathematical Statistics"; John Wiley. 4. Jaiswal M.C. : "Statistical Distributions"; (in Gujarati), University Book Publication Board. 5. Patel J.K. et al. : "Handbook of Statistics Distributions"; Marcel Dekker. 6. Mood A.M., Graybill F. and Boes D.C. : "Introduction to the Theory of Statistics"; McGraw Hill.
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 1st Semester

Course-104: Linear Algebra

<table>
<tr><td>Course Code</td><td>104</td></tr>
<tr><td>Course Title</td><td>Linear Algebra</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>1970</td></tr>
<tr><td>Purpose of Course</td><td>To make students conversant with matrix theory and related results those are base of other papers to be taught</td></tr>
<tr><td>Course Objective</td><td>To make students understand all the aspects of matrix theory which are used in different subsequent papers to be teach such as Multivariate Analysis, Design of Experiments, Econometrics, Stochastic Process etc.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, students will be able to:
CO1: Understanding and applying basic concepts of linear Algebra
CO2: Identifying applications of Matrix Algebra in statistics
CO3: Express and solve system of equations with multiple dimensions/variables in matrix notations
CO4: Understand use of determinants, inverse of a matrix rank, characteristic polynomial, Eigen values, Eigen vectors etc., other special types of matrices.
CO5: Understand concepts of linear transformation, linear product and quadratic equations with their applications.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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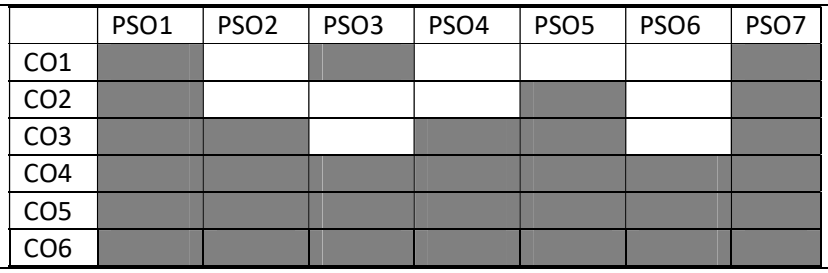
</td></tr>
<tr><td>Pre-requisite</td><td></td></tr>
<tr><td>Course Content</td><td>UNIT I:
• Fields, Vector Spaces, subspaces, linear dependence and independence, basis and dimension of a vector space, finite dimensional vector space, completion theorem. Vector spaces with an inner product, Gram-Schmidt orthogonalization process, orthogonal basis.

UNIT II:
• Symmetric, skew-symmetric, Hermitian, skew-hermitian, orthogonal, unitary and normal matrices. Laplace expansion method, Matrix polynomial, Rank of a matrix, Properties of rank of a matrix, Idempotent matrices, generalized inverses, Moore-Penrose generalized inverse.

UNIT III:</td></tr>
</table>

	• Real quadratic forms, reduction and classification of quadratic forms, index and signature, properties of quadratic forms. **UNIT IV:** • Characteristic roots and vectors, properties of characteristic roots and vectors of a real symmetric, hermitian, skew-hermitian, orthogonal, unitary and normal matrices, Algebric and geometric multiplicity of a characteristic root.
Reference Books	1. Gralbill F. A.: "Matrices with Applications in Statistics"; 2nd Ed., Wadsworth. 2. Rao C.R. : "Linear Statistical Inference and its Application"; 2nd Ed., John Wiley and Sons, Inc. 3. Searle S.R.: "Matrix Algebra useful for Statistics"; John Wiley and Sons, Inc. 4. Rao C.R. and Bhimasankaram P.: "Linear Algebra"; Tata McGraw Hill Pub.Co. Ltd. **Additional Books** 1. Bellman R. : "Introduction to Matrix Analysis"; 2nd. Ed., McGraw Hill. 2. Biswas S. : "Topics in Algebra of Matrices"; Academic pub. 3. Hadley G. : "Linear Algebra"; Narosa Pub. House. 4. Halmos P.R.: "Finite Dimensional Vector Spaces"; 2nd Ed., D. Van Nostrard Co. Inc. 5. Hoffman K. and Kunze R.: "Linear Algebra"; 2nd Ed., Prentice Hall, Inc. 6. Rao C.R. and Mitra S.K.: "Generalized Inverse of Matrices and its Application"; John Wiley and Sons, Inc.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course: 105: COMPUTER PROGRAMMING LANGUAGE – 'C'

Course Code	**105**
Course Title	**COMPUTER PROGRAMMING LANGUAGE – 'C'**
Credit	4
Teaching per Week	4 Hrs
Minimum weeks per Semester	15 (Including Class work, examination, preparation, holidays etc.)
Effective From	June 2008
Purpose of Course	The purpose of the course is to make the student capable of implementing the concepts, methods, and debugging tools of programming and learn their implementation.
Course Objective	To make students acquainted with knowledge of programming using C language.
Course Outcomes	After completing this course, students will be able to: CO1: Understand the basic concepts and fundamentals of programming such as algorithm and flowchart. CO2: Understand the basic C fundamentals such as data types, operators etc. CO3: Design programs involving control statements such as conditional and unconditional statements. CO4: Implement advanced programming approach such as modular programming along with parameter passing techniques. CO5: Understand the concept of different data structures such as array, structure and union. CO6: Develop the programs that deal with various operations on data files.
Mapping between COs with PSOs	
Pre-requisite	Basic knowledge of computer and typing skill is essential.

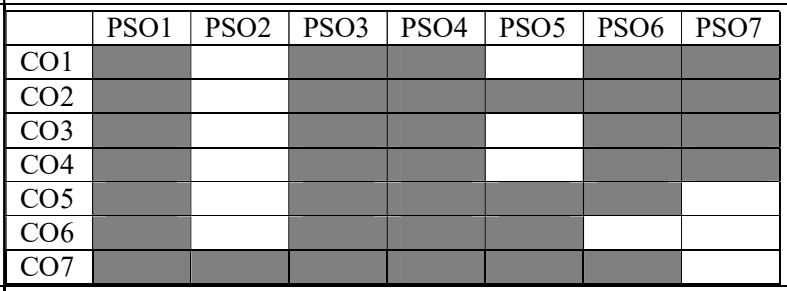
Course Content	**UNIT I:**
	• Introduction
	  ➢ Algorithms and Flowchart
	  ➢ Types of Language
	  ➢ Introduction to C Language
	• C Fundamentals
	  ➢ Identifiers
	  ➢ Data Types
	  ➢ Constants and Variables
	  ➢ Arrays
	• Operators and Expressions
	  ➢ Arithmetic Operators
	  ➢ Unary Operators
	  ➢ Relations Operators
	  ➢ Logical Operators
	  ➢ Assignment Operators
	  ➢ Conditional Operators

	➢ Library Functions ➢ Expressions ➢ Evaluation of Expression **UNIT II:** • Data Input and Output ➢ Single Character input and output ➢ The scanf function ➢ The printf function ➢ Gets and Puts functions • Control Statements ➢ The While Statement ➢ do-while statement ➢ for statement ➢ if - else statement ➢ switch statement ➢ break statement ➢ continue statement ➢ goto statement **UNIT III:** • Functions ➢ Introduction to functions ➢ Function definition ➢ Accessing function ➢ Passing arguments to function ➢ Recursive function • Data Files **UNIT IV:** • Arrays ➢ Defining an array ➢ Processing an array ➢ Multi dimensional arrays ➢ Passing array to a function ➢ Arrays and Strings • Structures and Unions ➢ Defining a structure ➢ Processing a structure ➢ Unions
Reference Books	1. Karnighan B. W. and Ritchie D. M. (1978) : "C programming Language"; Prentice Hall- Gale, **ISBN:** 0131101633, **ISBN-13:** 9780131101630 2. VijayMukhi: "The C Odyssey -vol. 6: Windows"; Bpb, **ISBN:8170291682**, **ISBN-13:** 9788170291688 3. Stephan G. Kochan (2001) : "Programming In C" ; CBS Publishers & Distributors, ISBN PB : CBS0000031 4. Stephen G. Kochan (2004): **"**Programming in C"; 3rd Edition, Sams, **ISBN-10:**0672326663, **ISBN-13:** 978-0672326660 5. Kelly Stan and Bootle (1988): "Mastering turbo C"; BPB Publications 6. Stan Kelly Bootle (1988): "Mastering Turbo C"; Wiley John & Sons Incorporated, ISBN-13: 9780895884626 , ISBN: 0895884623 7. Kanetkar Yashwant (2006) : "Let us C" ; 9th Edition , BPB, **ISBN:**

	8183331637, **ISBN-13:** 9788183331630, 8. E Balaguruswamy (2007) : "Programming In C#"; Tata Mgraw Hill, **ISBN:** 0070667578 **ISBN-13:** 9780070667570, 978-0070667570 9. Robert Lafor (2001) : "Object - Oriented Programming in C" ; Sams , 4th Edition, **ISBN:** 0672323087, **ISBN-13:** 9780672323089, 978-0672323089 10. Robert Lafore (1995) : "Object Oriented Programming in C++"; Galgotia Publications.
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 1st Semester

Course-106: Practical paper-I

Course Code	106
Course Title	Practical paper-I
Credit	4
Teaching per Week	8
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	2019-20
Purpose of Course	The purpose of this course is to enrich the computing power of students using MS office tools Excel.
Course Objective	Learning analysis of various kinds of data using excel will help the students to understand how to go around with the computing part of some of the theoretical aspects using MS office tools Excel.
Course Outcomes	After successful completion of this course, student will be able to: CO1: Handle and process the data using excel CO2: Perform the analysis with analysis tool pack in excel CO3: Customize menus and toolbars in excel CO4: Understand and apply various functions available in excel. CO5: Solve linear algebra problems by excel CO6: Fit the distributions to a real life data CO7: Perform statistical formula using C programming
Mapping between COs with PSOs	
Pre-requisite	Basics knowledge of computer, Basics of mathematics and Statistics
Course Content	Based on theory paper 101 to 105
Reference Books	Reference book mention in theory paper 101 to 105
Teaching Methodology	Classwork, Discussion, Lab work, self-study, practical session, Live demo, hands on training.
Evaluation Method	30% Internal assessment based on class attendance, journal, internal practical examination, VIVA etc. 70% External based on semester end University examination.

M. Sc. Statistics 2nd Semester

Course-201: Estimation Theory

Course Code	201
Course Title	Estimation Theory
Credit	4
Teaching per Week	4
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	2019-20
Purpose of Course	This paper deals with point estimation, types of estimation and interval estimation. From this paper the students are expected to build a foundation on inferential statistics which is the basis of higher-level mathematical statistics.
Course Objective	The purpose of this course is to derive suitable point estimators of the parameters of the distribution of a random variable and give a measure of their precision and to learn computational skills to implement various statistical inferential approaches.
Course Outcomes	After completion of this course, the students will be able to: CO1: Understand the concept of estimator with different properties CO2: Demonstrate and understanding the concept of unbiasedness and biasedness with theory CO3: Derive a foundation on different theorem based on estimators CO4: Describe the concept of BLUE, BAN, MVUE, MVBUE, UMVUE with theorems. CO5: Students have the knowledge methods of obtaining minimum variance unbiased estimators. CO6: Learn the methods for interval estimation for small and large size confidence internal
Mapping between COs with PSOs	
Pre-requisite	Basic of probability distributions, calculus and estimation theory
Course Content	**UNIT I:** • Concept of Estimator and Estimate, Different measures of closeness of an estimator: Pitman's closeness. Some desirable properties of estimators: Definition of Unbiasedness and Biasedness, Definition of Consistent estimator, Theorem of derivation of Consistent estimator, Efficiency: Best linear combination of unbiased estimator, BAN estimators. Sufficient statistics.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1							
CO2							
CO3							
CO4							
CO5							
CO6							

	UNIT II: • Neyman factorization theorem for discrete case, Minimal sufficient statistics, complete sufficient statistics, Minimum variance unbiased estimation: Lower bound of variance of an unbiased estimator, Cramer–Rao inequality, Minimum variance bound unbiased estimators, condition of existence of Minimum Variance Bound Unbiased Estimator. Chapman-Robbins inequality, Bhattacharya inequality, Rao-Blackwell theorem. Lehmann –Scheffe theorem, One parameter family of exponential distribution, Concept of finding uniformly minimum variance unbiased estimator (UMVUE) **UNIT III:** • Maximum likelihood estimator and its properties. Method of maximum likelihood, other methods of estimation: Method of moments, Method of minimum chi-square, Method of modified minimum chi squares, Method of scoring, MLE for grouped data, Method of scoring, Location invariance and scale invariance estimator and parameter, Pitman estimators for location and scale parameters. **UNIT IV:** • Confidence intervals: Methods of finding confidence interval, Large sample confidence intervals, confidence intervals for parameters of elementary distributions, confidence bounds of fixed length, Stein's two-stage procedure.
Reference Books	**REFRENCES** 1. Rohatagi V.K. : "An Introduction to Probability Theory and Mathematical Statistics". 2. Rao C.R. : "Linear Statistical Inference and its Applications"; John Wiley. 3. Mood A.M., Graybill F. and Boes D.C. : "Introduction to the Theory of Statistics"; McGraw Hill. 4. Lehmann E.L.: "Theory of Point Estimation"; John Wiley. 5. Ferguson T.S.: "Mathematical Statistics: A Decision Theoretic Approach"; Academic Press. 6. Zacks S. : "Theory of Statistical Inference"; John Wiley.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 2nd Semester

Course-202: Multivariate Analysis

<table>
<tr><td>Course Code</td><td>202</td></tr>
<tr><td>Course Title</td><td>Multivariate Analysis</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>2019-20</td></tr>
<tr><td>Purpose of Course</td><td>The purpose of this course is to understand the extensions of univariate techniques to multivariate frameworks and learn to apply dimension reduction techniques used in the data analysis with the use of probability distributions.</td></tr>
<tr><td>Course Objective</td><td>In multivariate analysis students learn how to deal with the data analysis of several variables simultaneously. Necessary theoretical deductions of different multivariate techniques and deduction of multivariate probability distributions are the learning objectives of this paper.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, the students will be able to:
CO1: Understand the development of multinomial and multivariate normal distribution with their properties.
CO2: Understand the concept of Wishart distribution with various properties
CO3: Understand the idea of partial and multiple correlation coefficient with testing of hypothesis
CO4: Get Derivation of Hotelling T^2 statistic and their various application in real life problems
CO5: Demonstrate the knowledge and understanding of the basic ideas behind classification and discriminant analysis
CO6: Understand the concept of data reduction technique like factor, principal and Canonical correlation analysis</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table><tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr><tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>Pre-requisite</td><td>Univariate distribution in both cases discrete and continuous, concept of linear algebra</td></tr>
<tr><td>Course Content</td><td>UNIT I:
● Multivariate distributions: Multinomial distribution, Marginal and Conditional distributions, Characteristic function.</td></tr>
</table>

	Multivariate Normal distribution, Characteristic function, Marginal and conditional distributions, Distribution of linear function. Distribution of sample mean vector. **UNIT II:** ● Distribution of sample generalized variance. Wishart Distribution: p.d.f of Wishart distribution, Properties of Wishart distribution, Additive property, Distribution of HWH', marginal distribution of W_{11}, distribution of h'wh/h'Σh, h'Σ^{-1}h/h'w^{-1}h, Characteristic function. • Null and Non-null distribution of sample correlation coefficient r. Definition of Multiple and partial correlation coefficients. Null distributions of sample multiple and partial correlation coefficients. Testing of H_0: (i) $\rho = 0$, (ii) $\rho = \rho_0$ (iii) $\rho_{1(2.p)} = 0$ (iv) $\rho_{12.3\ldots p} = 0$ (v) $\rho_{12.3\ldots p} = \rho_0$ **UNIT III:** ● Hotelling T^2 statistic. Null distribution of T^2, application in tests on mean vector for one and two multivariate normal populations and in testing equality of the components of mean vector (Problem of symmetry). ● Multivariate Analysis of variance (MANOVA): One-Way classification problem. **UNIT IV:** ● Classification Problem and Fisher's linear discriminant function, Probabilities of misclassification, Classification with more than Two multivariate normal populations. ● Concept and application of (i) Factor analysis (ii) Principal Component analysis and (iii) Canonical Correlation analysis.
Reference Books	1. Anderson T. W. : "An Introduction to Multivariate Statistical Analysis"; John Wiley. 2. Johnson and Wichern : "Applied Multivariate Statistical Analysis". 3. Khirsagar A. M. : "Multivariate Analysis"; Marcel Dekker. 4. Morrison D.F.: "Multivariate Statistical Methods"; McGraw Hill. 5. Muirhead R.J. : "Abstracts of Multivariate Statistical Theory"; John Wiley. 6. Seber G.A.F. : "Multivariate Observations"; John Wiley. 7. Srivastava and Khatri C.G.: "An Introduction to Multivariate Statistics"; North Holland
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment

Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 2nd Semester

Course-203: Sampling Theory

<table>
<tr><td>Course Code</td><td>203</td></tr>
<tr><td>Course Title</td><td>Sampling Theory</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>1970</td></tr>
<tr><td>Purpose of Course</td><td>The purpose of the course is to provide the knowledge of sample survey and sampling designs starting with the basic concepts.</td></tr>
<tr><td>Course Objective</td><td>The objective of this course is to acquaint the students about the need & merits of sampling over census, theoretical and practical applications of different probabilistic, non-probabilistic sampling techniques and point estimation & interval estimation of different parameters of interest under different sampling techniques.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, the students will be able to:
CO1: Understand the basic principles of survey design and estimation.
CO2: Apply different sampling methods, like SRSWR, SRSWOR, post–stratification (stratified sampling), Systematic sampling, Cluster sampling, Two stage sampling, multistage sampling for designing and selecting a sample from population under study and estimation of parameter of interest.
CO3: Have Theoretical understanding and practical applications of use of auxiliary variable at estimation stage, e.g. Ratio, product and Regression methods of estimation under different sampling techniques and use of two phase /double sampling.
CO4: Apply unequal probability sampling designs viz. PPSWR, PPSWOR including cumulative sum method, Lahiri’s method, sen-midzuno sampling.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table><tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr><tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>Pre-requisite</td><td>Probability theory and Basics of Statistical inference.</td></tr>
<tr><td>Course Content</td><td>UNIT I:
• Basic concepts of sample survey and sampling theory:
➢ Concepts of population and sample need for sampling, Census and sample survey, basic concepts in sampling, organizational aspects of survey sampling, sample selection and sample size.
➢ Concept of parameter, statistic, sampling distribution and standard error, revision of properties of good estimator and criteria for comparison of estimators.</td></tr>
</table>

	UNIT II: • **Basic Probabilistic Sampling techniques:** ➢ Simple random sampling ➢ Stratified sampling ➢ Systematic sampling and ➢ Cluster sampling (with equal and unequal cluster sizes) **UNIT III:** • **Methods of estimation in sampling:** ➢ Ratio method of estimation- Ratio estimator , unbiased ratio estimator and almost unbiased ratio estimator ➢ Product method of estimation ➢ Regression method of estimation ➢ Difference estimator **UNIT IV:** • **Advanced Probabilistic sampling techniques:** ➢ Two–stage sampling and its generalization. ➢ Two phase sampling for ratio and regression estimators. ➢ Probability Proportional to size sampling (with and without replacement), Sen-Midzuno sampling scheme
Reference Books	1. Cochran W. G. : "Sampling Techniques"; John Wiley & Sons, Inc., New York. 2. Hansen M. H., et al.: "Sample Survey Methods and Theory"; John Wiley & sons, Inc., New York. 3. Kish L. : "Survey Sampling"; John Wiley & Sons, Inc., New York. 4. Murthy M. N. : "Sampling Theory and Methods"; Statistical Publishing Society, Calcutta. 5. Raj D. : "Sampling Theory"; McGraw-Hill Book co., New York. 6. Raj D. : "The Design of Sample Surveys"; McGraw-Hill Book Co., New York. 7. Sukhatme P.V., et al.: "Sampling Theory of Surveys with Applications"; The Iowa State Univ. Press, Ames, Iowa, USA and Indian Society of Agricultural Statistics, New Delhi. 8. Yates F. : "Sampling Methods in Censuses and Surveys"; Charles Griffin & Co. Ltd., London. 9. Goulden C. H. : "Methods of Statistical Analysis", Asia Publishing House, Bombay. 10. Snedecor G.W. and Cochran W.G. : "Statistical Methods"; The Iowa State Univ. Press, Ames, Iowa, USA.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation,

	class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course: 204: Actuarial Statistics

<table>
<tr><td>Course Code</td><td>204</td></tr>
<tr><td>Course Title</td><td>Actuarial Statistics</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4 Hrs</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Class work, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>June 2019</td></tr>
<tr><td>Purpose of Course</td><td>The purpose of this course is to learn the life tables used in insurance products. • To learn the concept of interest, different life insurance products, life annuities, net premiums. • To motivate students to prepare for exams required for employment in the actuarial science profession.</td></tr>
<tr><td>Course Objective</td><td>To make students acquainted with actuarial science and implementation of statistics in actuarial science</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, students will be able to:
CO1: Understand the utility theory, insurance products and life tables.
CO2: Understand the concept of interest.
CO3: Understand the concept of life insurance and the existing insurance products of different insurance company.
CO4: Know life annuities, net premium and net premium reserves.
CO5:Understaand the concept of Stationary population and various models</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><th></th><th>PSO1</th><th>PSO2</th><th>PSO3</th><th>PSO4</th><th>PSO5</th><th>PSO6</th><th>PSO7</th></tr>
<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Pre-requisite</td><td>Basics concepts of actuarial statistics and insurance policy planning</td></tr>
<tr><td>Course Content</td><td>UNIT I:
• Basics of Probability & Interest: Theory of Interest, Variable interest rates, continuous time payment streams.
• Interest & Mortality: Annuities, Loan Amortization and Mortgage Refinancing, Mortality and Analytical models.
UNIT II:
• Life Tables: Concepts of Life Tables, Assumptions related to life tables, columns of life tables, Complete and Abridged life tables, Construction of life tables, Estimation from life table data
UNIT III:
• Expected present values of payments, Continuous contracts & residual life, Premium calculations, m-payment net single premiums
• Population functions and indicator notations, Stationary population concepts
UNIT IV:
• Risk models: Proportional Hazard models, excess risk models, Multiple decrement models, death rate estimators, causes specific life insurance premiums</td></tr>
<tr><td>Reference Books</td><td>1. Barcley G.W. (1970). Techniques of Population Analysis. John Wiley, New York.</td></tr>
</table>

	2. Borowiak, D.S., and A. F. Shapiro. (2013). Financial and Actuarial Statistics: An Introduction, Second Edition. CRC Press. 3. Donald, D.W.A. (1970). Compound interest and annuities, Second Edition, The Institute of Actuaries and the Faculty of Actuaries at the University Press. 4. Spurgeon, E.T. (2011), Life Contingencies, Third Edition, Cambridge University Press. 5. Eric V. Slud (2001): Actuarial Mathematics and Life Table Statistics (Mathematics Department, University of Maryland)
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 2nd Semester

Course-205: Linear Models

<table>
<tr><td>Course Code</td><td>205</td></tr>
<tr><td>Course Title</td><td>Linear Models</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>2019-20</td></tr>
<tr><td>Purpose of Course</td><td>Main purpose of this course if to introduce need of the modelling for different real life phenomenon as a linear model and its statistical significance and interpretation.</td></tr>
<tr><td>Course Objective</td><td>The main objective of this course is to provide the theoretical foundation of the Linear models and related aspects of estimation and testing of hypotheses related to its parametric functions.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, students will be able to:
CO1: To understanding general linear models under Gauss-Markoff set up (GMLM and GGMLM) including parameter estimation using method of least squares and its significance testing
CO2: To understand the use and need of restricted linear regression and related theory
CO3: To understand the process of simultaneous estimation of parametric functions, use of quadratic form, canonical form etc for different purposes.
CO4: Cochran’s theorem and its application for linear models</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Pre-requisite</td><td>Linear Algebra, Probability theory, Estimation theory, Testing of Hypotheses, Multivariate analysis</td></tr>
<tr><td>Course Content</td><td>UNIT I:
• The general linear model: Gauss-Markoff set up, least squares, and generalized least squares, Normal equations and least squares estimates, estimation of linear parametric functions, variances and covariances of least squares estimates, estimation with correlated observations.

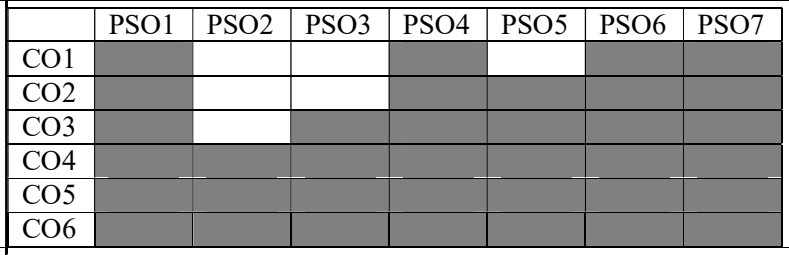
UNIT II:
• Least squares estimates with restrictions on parameters, simultaneous estimates of linear parametric functions, Canonical form of the linear hypothesis model and Error and Estimation spaces.

UNIT III:
• Estimation of scale parameter in the general linear model by</td></tr>
</table>

	quadratic functions. Necessary and sufficient conditions for (i) a quadratic form to be distributed as chi-square (ii) independence of a linear form and a quadratic form (iii) independence of two quadratic forms. **UNIT IV:** • Cochran's theorem and its generalizations. • Tests of hypotheses regarding parameters of a general linear model, tests involving linear functions of parameters, tests of sub hypotheses.
Reference Books	1. Rao C.R. (1973): "Linear Statistical Inference and its Applications"; 2nd Ed., John Wiley and Sons, Inc. 2. Searle S.R. (1971): "Linear Models". 3. Seber G.A.F. (1977): "Linear Regression Analysis". 4. Graybill F. A. (1961): "An Introduction to Linear Statistical Models". 5. Kshirsagar A.M.(1983): "A Course in Linear Models".
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 2nd Semester

Course-206: Practical paper-II

Course Code	206
Course Title	Practical paper-II
Credit	4
Teaching per Week	8
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	2019-20
Purpose of Course	The purpose of this course is to enrich the computing power of students using MS office tools Excel.
Course Objective	Learning analysis of various kinds of data using excel will help the students to understand how to go around with the computing part of some of the theoretical aspects using MS office tools Excel.
Course Outcomes	After successful completion of this course, student will be able to: CO1: Handle and process the data using excel CO2: Perform the analysis with analysis tool pack in excel CO3: Understand and apply various functions available in excel. CO4: Estimate parameters using formula in excel by different methods CO5: Solve problem related multivariate data with use of excel CO6: Apply sampling technique to solve real life problem using excel
Mapping between COs with PSOs	
Pre-requisite	Basics knowledge of computer, Statistical inference, Multivariate technique, Sampling Technique and Actuarial Statistics
Course Content	Based on theory paper 201 to 205
Reference Books	Reference book mention in theory paper 201 to 205
Teaching Methodology	Classwork, Discussion, Lab work, self-study, practical session, Live demo, hands on training.
Evaluation Method	30% Internal assessment based on class attendance, journal, internal practical examination, VIVA etc. 70% External based on semester end University examination.

M. Sc. Statistics 3rd Semester

Course-301: Testing of Hypothesis

<table>
<tr><td>Course Code</td><td>303</td></tr>
<tr><td>Course Title</td><td>Testing of Hypothesis</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>1970</td></tr>
<tr><td>Purpose of Course</td><td>The purpose of this course is to teach classical theory of testing of hypotheses, use of the concept of likelihood of testing of hypothesis and sequential testing of hypothesis for different types of hypothesis and their applications.</td></tr>
<tr><td>Course Objective</td><td>To make students aware of Neyman-Pearson Theory of testing of hypotheses, likelihood ratio based parametric testing (simple, as well as, composite hypotheses) and sequential testing (simple) procedures.</td></tr>
<tr><td>Course Outcomes</td><td>After successful completion of this course, student will be able to:
CO1: Formulate null and alternative hypotheses; understand types of errors involved in the testing of hypotheses, concepts for comparisons of different possible test procedures to decide the best test for various types of null and alternative hypotheses for different real life situations.
CO2: Compute probabilities of types of error, MP tests and MLR property.
CO3: Understand UMP and UMPU test with their applications and relevant results
CO4: Knowledge of construction of MP test, UMP test and UMPU test. - Knowledge of SLRT & GLRT and SPRT. – Knowledge of Interval Estimation
CO5: Concept and related results of invariant testing of hypotheses and their applications</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><th></th><th>PSO1</th><th>PSO2</th><th>PSO3</th><th>PSO4</th><th>PSO5</th><th>PSO6</th><th>PSO7</th></tr>
<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Pre-requisite</td><td>Detailed knowledge Probability theory, Estimation theory probability distributions.</td></tr>
<tr><td>Course Content</td><td>UNIT I:
• Basic concepts of testing of hypotheses
Statistical Hypotheses- Simple and Composite. Statistical tests, Critical region, randomized test, non–randomised test, Errors of Type I and Type II, Size and Power of a test
• MP and UMP tests
Neyman–Pearson’s Lemma & Generalized Neyman–Pearson’s Lemma and</td></tr>
</table>

	its applications to find Most Powerful test and UMP tests for families of distributions admitting monotone likelihood ratio, two sided hypotheses **UNIT II:** • **Unbiasedness for testing of hypotheses:** Similar test, relationship with UMP unbiased test, UMP similar test and its application for one parameter exponential family, Similarity and completeness, tests with Neyman structure, UMP unbiased tests for multi-parameter exponential families **UNIT III:** • **Concept of Invariance in testing of hypotheses:** Maximal invariant test, most powerful invariant test • **Concept of least favourable distribution and its use in testing of hypotheses** **UNIT IV:** • **Liskelihood ratio tests:** Likelihood ratio test for simple and composite hypotheses. **UNIT V:** • **Sequential testing of hypotheses:** Wald's sequential probability ratio test (SPRT), Properties of SPRT, approximate bounds, OC and ASN functions, Efficiency of SPRT, Fundamental identity of sequential analysis and its use to obtain OC and ASN functions of SPRT.
Reference Books	1. Ferguson T.S. : "Mathematical Statistics"; Academic Press. 2. Kendall M.G. and Stuart A.: "The Advanced Theory of Statistics"; Vol. 2., Ed. IV, Charles and Griffin. 3. Lehman E.L. : "Testing Statistical Hypotheses"; Wiley Eastern. 4. Mood A.M., Grabill F. and BoesD.C. : "Introduction to the Theory of Statistics"; McGraw Hills, International Student Ed. III. 5. Rao C.R. : "Linear Statistical Inference and its Applications"; Wiley Eastern, EdII. 6. S. Wilks : "Mathematical Statistics", Wiley New York. 7. S. Zacks : "The Theory of Statistical Inference"; Wiley New York. 8. Goon A. M., Gupta M. K. and Dasgupta B. : "An Outline of Statistical Theory" Vol.1, 2; World press. 9. Rohatgi V.K.: "Introduction to Probability Theory and Mathematical Statistics"; Wiley Eastern.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 3rd Semester

Course-302: Econometrics

<table>
<tr><td>Course Code</td><td>302</td></tr>
<tr><td>Course Title</td><td>Econometrics</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Class work, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>1970</td></tr>
<tr><td>Purpose of Course</td><td>The purpose of this course is to give students a proper and thorough understanding of the applications of linear and non-linear regression models, its limitations and foundation in econometric techniques for forecasting. This will enable students to develop regression model and apply for the specific perspective fields/ data sets.</td></tr>
<tr><td>Course Objective</td><td>The objective of this course is to introduce the subject of econometrics from its origin to its advance developments with their application for studying economic phenomena and hence to introduce branch which is an integration of mathematics, statistics, and economics.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, the students will be able to:
CO1: Understand importance of descriptive techniques, graphical techniques and correlation analysis before using regression analysis and drawing inference out of it.
CO2: Apply simple linear regression model to real life data/ situations
CO3: Understand multiple linear regression models with applications and concept of Multicollinearity, autocorrelation and heteroscedasticity.
CO4: Residual analysis for validation of the fitted model as well as identifying the problems with the fitted model.
CO5: To suggest the correct regression model for the given problem
CO6: To analyse the robustness of the regression model.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>CO6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Pre-requisite</td><td>Linear algebra, Linear Models, Probability theory, Estimation theory, Testing of Hypotheses, Probability distributions</td></tr>
<tr><td>Course Content</td><td>UNIT I:
• Econometrics, Introduction to econometric models. Review of Single Equation method OLS estimation: Estimation, Prediction, and tests of hypotheses, G.L.M. and generalized least squares estimation. Aitken's generalized least square (G.L.S) estimator,

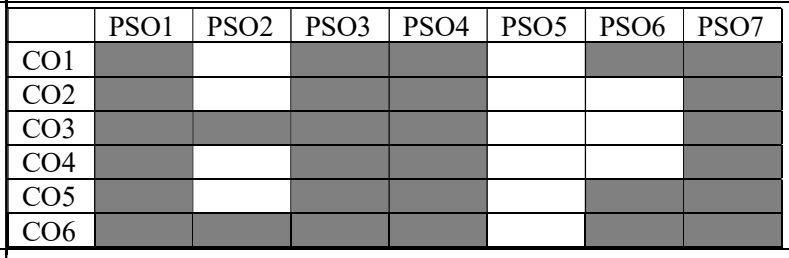
UNIT II:</td></tr>
</table>

	• GLM with stochastic regressors. Instrumental variables, estimation, consistency property, asymptotic variance of instrumental variable estimators. • **Dummy and Lagged variables:** The nature of dummy variables, caution in the use of dummy variables, ANOVA models with two qualitative variables, regression with a mixture of quantitative and qualitative regressors: the ANCOVA models, the dummy variable alternative to the chow test, interaction effects using dummy variables, the use of dummy variables in seasonal analysis, piecewise linear regression. **UNIT III:** • **Autocorrelation :** Introduction, its consequences and tests and remedial measures to it. • **Heteroscedasticity:** Problem of hetroscedasticity, Consequence of hetroscedasticity, Tests for detecting the presence and nature of hetroscedasticity, Methods for handling hetroscedasticity. Grouping of observations. • **Multicollinearity:** Detection and consequences, tools for handling multicollinearity, ridge regression and properties of ridge regression. **UNIT IV:** • **Simultaneous equation system:** structure and models, typology of economic relations, structural form, reduced form and final form of an economic model. Problem of identification under linear homogeneous and Covariance restrictions. Rank and Order conditions of Identification, Restrictions on structural parameters. • **Methods of estimation:** Limited information models, indirect least squares. Two stage least squares, limited information maximum likelihood (LIML), full information methods. Three stage least square (3SLS) and full information maximum likelihood (FIML). K-class estimators, Instrumental variable method of estimation, 3-SLS estimation.
Reference Books	1. Apte P.G.: "Text Book of Econometrics"; Tata McGraw Hill. 2. C. F. Charist: "Econometric Models and Methods"; John Wiley. 3. Chatterjee and Price B.: "Regression Analysis by Example"; John Wiley & Sons. 4. Cramer: "Empirical Econometrics"; North Holland. 5. D.Gujarati: "Basic Econometrics"; McGraw Hill. 6. Intriligatore,M.D. : Economic models -techniques and applications, Prentice Hall 7. Intrilligtor H.: "Econometric Methods, Techniques and

	Applications"; Prentice Hall Pub. Co. 8. J. Jonston: "Econometric Methods"; McGraw Hill, Kogakusha Ltd. 9. Jan Kmenta : Elements of Econometrics, University of Michigan Press 10. Judge, G.C., Hill, R, C. Griffiths, W.E., Lutkepohl, H. and Lee, T-C. (1988). Introduction to the Theory and Practice of Econometrics, Second Edition, John Wiley & Sons. 11. Kendall, M.G. and Stuart, A. (1968). The Advanced Theory of Statistics (Vol. III), Second Edition, Charles Griffin. 12. Klein L.R.: "An Introduction to Econometrics"; Prentice Hall of India. 13. Klein, L.R. : Applied Economics, Taylor and Francis 14. Kmenta, J. (1986). Elements of Econometrics, Second Edition, Mac Millan. 15. Kontsoyiannis A.: "Theory of Econometrics"; Mac Millan press. 16. Maddala, G.S. : Econometrics, North Holland 17. Malinvad E.: "Statistical Methods in Econometrics"; North Holland. 18. Theil H. C.: "Introduction to the Theory and Practice of Econometrics"; John Wiley.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 3rd Semester

Course-303: Operations Research I

Course Code	303
Course Title	Operations Research I
Credit	4
Teaching per Week	4
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	1970
Purpose of Course	The purpose of this course is to Study Operations research (OR) which is an analytical method of problem-solving and decision-making that is useful in the management of organizations.
Course Objective	To learn the mathematical formulation of complex decision-making problems and arrive at optimal or near-optimal solutions using different techniques of operations research.
Course Outcomes	After completing this course, the students will be able to: CO1: Understand the basics and formulation of linear programming problems, solve linear programming problems using graphical method, simplex, two-phase and Big-M method. CO2: Become aware of transportation problem with their properties, methods and real-life applications. CO3: Understand concept of the assignment problem with real life situations. CO4: Understand the concept of duality, their properties and methods CO5: Develop the concept of simulation, their type and applications CO6: Understand the concept of inventory management system with EOQ model with different scenario like probabilistic and deterministic
Mapping between COs with PSOs	
Pre-requisite	Concept of liner algebra, basic mathematical operations
Course Content	**UNIT I:** • **Linear Programming:** ➢ Definition of linear programming problem (LPP) ➢ Formulation of LPP . ➢ Solution of LPP by Graphical and Simplex Method (including Big-M and Two-phase method)

	UNIT II: • **Transportation and Assignment Problems:** ➢ Definition of Transportation Problem (TP) ➢ Special structure of TP ➢ Methods for getting basic feasible solution to TP ➢ Methods for getting optimum solution to TP ➢ Unbalanced TP ➢ Definition of Assignment Problem (AP) ➢ Algorithm for solving an AP ➢ Unbalanced AP ➢ Routing Problem **UNIT III:** • **Duality:** ➢ Definition of Dual Problem. ➢ Rules for converting any Primal into its Dual ➢ Properties of Duality ➢ Dual-Simplex Method • **Simulation** ➢ Introduction & definitions ➢ Types of simulation ➢ Uses & limitation ➢ Phases of simulation Model ➢ Even type simulation ➢ Monte-Carlo Simulation & its applications ➢ Advantages and Disadvantages **UNIT IV:** • **Inventory Management Systems:** ➢ Definition ➢ Costs involved in Inventory Problems ➢ Classical EOQ Models without and with shortages ➢ Multi-item Deterministic Models ➢ Probabilistic Inventory Models ➢ Inventory Models with Price Breaks
Reference Books	1. K. Swarup, Gupta P.K. and Man Mohan : "Operations Research"; S.Chand & Co.,New Delhi. 2. G. Hadley : "Linear Programming"; Oxford & IBH Pub. Co. 3. Murthy K.G. : "Linear and Nonlinear Programming".

	4. Kasana H.S. and Kumar K.D. : “Introductory Operations Research”; Springer. 5. Kapoor V.K. : “Operations Research”; S.Chand & Co.,New Delhi. 6. Sharma S.D. : “Operations Research”; Kedar Nath Ram Nath & Co. Publishers, Meerut.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 3rd Semester

Course-304: Introduction to Statistical Softwares

<table>
<tr><td>Course Code</td><td>304</td></tr>
<tr><td>Course Title</td><td>Introduction to Statistical Softwares</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>2019-20</td></tr>
<tr><td>Purpose of Course</td><td>This is a course after studying which students can perform different statistical computations using statistical package and can think a career on data analysis and even get self-employed as a data analyst.</td></tr>
<tr><td>Course Objective</td><td>To learn statistical techniques and their implementation using comprehensive SPSS software and R</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, the students will be able to:
CO1: Get familiar with SPSS software and understand SPSS environment.
CO2: Create and edit the data files, plot graphs using SPSS.
CO3: Compute descriptive statistics using SPSS.
CO4: Perform inferential statistical analysis through SPSS.
CO5: Understand basics of R environment.
CO6: Perform various operations on data in R.
CO7: Do descriptive statistical analysis in R.
CO8: Perform different computational facilities provided in the package.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
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<tr><td>CO7</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO8</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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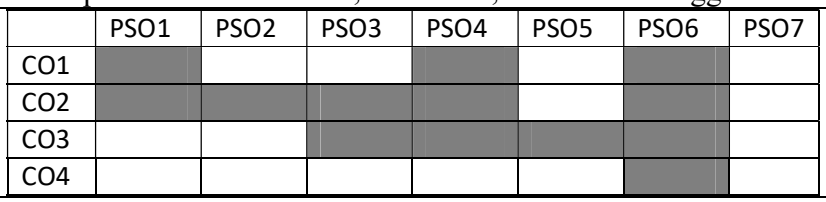
</td></tr>
<tr><td>Pre-requisite</td><td>Basics of computer and Statistical inference</td></tr>
<tr><td>Course Content</td><td>UNIT I:
• SPSS:
➢ SPSS Introduction
➢ Starting SPSS
➢ Types of Data
➢ Levels of Measurement
➢ Missing Values</td></tr>
</table>

	➢ Important Files // database files • **Data Management** ➢ Selecting Cases ➢ Standardizing Data ➢ Transformation of Data ➢ Split File ➢ Variable and Value Labels ➢ Recode Variables/Visual Binning ➢ Random Sample of the Data ➢ Creating a Population Variable ➢ Multi Response ➢ Time Saving Features / SPSS MACRO **UNIT II:** • **Basic Data Analysis** ➢ Descriptive Statistics ➢ Frequency Tables/Cross Tabs ➢ Independent T test ➢ Paired T Test ➢ One-Way ANOVA ➢ Correlation / Regression • **Interpret the Results** Presentation with live data **UNIT III:** **R:** • **Introduction to R** ➢ Background and resources ➢ Installing R. ➢ R console. ➢ R commander ➢ Command and syntax ➢ Packages and libraries ➢ Help in R ➢ Workspace in R • **Data Structures** ➢ Introduction to data structure ➢ Vectors ➢ Matrices ➢ Arrays ➢ Lists ➢ Factors

	➢ Data frames ➢ Importing and Exporting data ➢ Data types • **Frequencies & Descriptive Statistics** ➢ Frequency ➢ Measure of central tendency ➢ Measure of Dispersion ➢ Measure of skewness ➢ Box and Whisker part • **Data management** ➢ Split ➢ Find and replacement ➢ Manipulations with alphabets ➢ Evaluation of strings ➢ Data frames. **UNIT IV:** • **Graphical Analysis** ➢ Creating a simple graph ➢ Modifying the points and line of graph ➢ Modifying title and subtitle of a graph ➢ Modifying axes of the graph ➢ Adding additional elements to graph ➢ Adding legend on a graph ➢ Special graph ➢ Multiple plots • **Comparing Populations** ➢ Cross tabulation ➢ One sample t test ➢ Independent sample t test ➢ Paired sample t test ➢ One way ANOVA • **Bivariate Data Analysis** ➢ Correlation ➢ Simple linear regression ➢ Multiple linear regression • **Conditional executions and loops** ➢ If loop ➢ While loop ➢ For loop

Reference Books	1. Miller R. L., Ciaran Acton and Fullerton D. A., John Malthy(2009), "SPSS for Social Scientists"; 2nd Edition, Palgrave Macmilan. ISBN: 9780230209930. 2. Wagner W. E. III (2006): "Using SPSS for Social Statistics and Research Methods"; SAGE Publications, ISBN-13: 9781412940771. 3. Einsprucho E. L.: "An Introductory Guide to SPSS for Windows"; ISBN:1-412904153. 4. Pandya K. and Bulsari S.: "Enjoy Statistics with SPSS for Windows"; Popular. 5. Gaur A. S. and Gaur S. S(2009).: "Statistical Methods for Practice and Research- A guide to data analysis using SPSS"; 2nd Ed., Sage Publications, New Delhi. 6. George: "SPSS For Windows: Step By Step"; 8th Ed., Pearson, ISBN: 8131724298, 9788131724293. 7. Sudha G. Purohit, Sharad D. Gore, and Shailaja R. Deshmukh (2008), "Statistics using 1. R, Second edition" , Narosa Publishing House, ISBN-978-81-8487-455-6 8. Dr. Mark Gardener (2015), "Beginning R: The statistical programming language", Wiley, ISBN-978-81-265-4120-1 9. Jared P. Lander (2014), "R for everyone advance analytics and graphics", Addison Wesley data & analytics series, Dorling Kindersley (India) Pvt. Ltd., ISBN-978-93-325-3924-2 10. Yanchang Zhao and Yonghua Cen (2014), "Data mining application with R",Elsevier, ISBN-978-93-5107-218-8 11. Nina Zumel and John Mount (2015), "Practical data science with R", Dreamtech Press, ISBN-978-93-5119-437-8 12. Paul D. Lewis (2010), "R for medicine and biology", Jones and Bartlett Publishers, ISBN-978-0-7637-5808-0.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course: 3051: DATABASE MANAGEMENT SYSTEMS

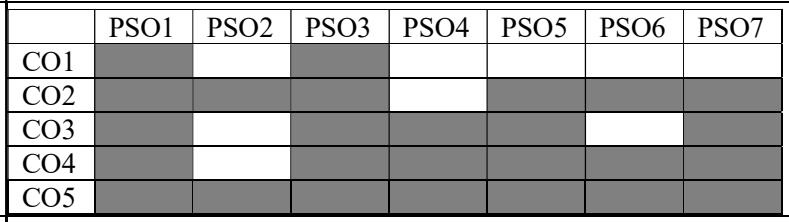
Course Code	**MAS-3051**
Course Title	**DATABASE MANAGEMENT SYSTEMS**
Credit	4
Teaching per Week	4 Hrs
Minimum weeks per Semester	15 (Including Class work, examination, preparation, holidays etc.)
Effective From	June 2020
Purpose of Course	The purpose of the course is to prepare the students to be capable of doing any kind of data management that will further help them to perform various activity of data science. The core objective of this course is to identify different database systems, their models and to perform various data management task such as retrievation, insertion and removation of data using it's tool.
Course Objective	To make students familiar with database management theory and give practical exposure to manage data using query language.
Course Outcomes	After completing this course, students will be able to: CO1: Understand and apply the concept of database management system by comparing them with traditional data management techniques; CO2: Perform data definition, data manipulation, data control and transaction control using Query language CO3: Learn fundamental data models and its application in real world domain. CO4: Extend the procedural structural query language using various concept such as Procedures, Functions, Cursor and Triggers
Mapping between COs with PSOs	
Pre-requisite	Fundamental of computer programming
Course Content	**UNIT I:** • Overview of Database Management System ➢ Introduction to Database Languages ➢ Advantages of DBMS over file processing systems. • Relational Database Management System ➢ Entity relationship model ➢ Mapping constraints ➢ Primary Keys ➢ Foreign Keys ➢ Structural Constraints ➢ ER notations & ER model ➢ Enhanced Entity Relationship Model **UNIT II:** • Database System ➢ Database Structure ➢ Levels of abstraction in DBMS ➢ View of data ➢ Role of Database users and administrators

	➢ Database Structure: DDL, DML, DCL,TCL **UNIT III:** • Types of Data Models ➢ Hierarchical databases ➢ Network databases ➢ Relational databases ➢ Object oriented databases **UNIT IV:** • PL/SQL ➢ Stored Procedure ➢ Concepts Procedure, Functions, Cursors ,Triggers
Reference Books	**1.** An Introduction to Database System- C. J. Date-Narosa **2.** Database System Concepts-Henry F. Korth & Abraham Silberschatz-McGraw-Hill **3.** Principles of Database System-J. Ullman-Galgotia Pub. **4.** Introduction to database system - Bipin C. Desai - Galgotia pub. **5.** Fundamentals of Database System-Elmasri Navathe, Addison Wesley **6.** Introduction to Databased Management- Navin Prakash - TMH **7.** Oracle PL/SQL Programming-Feuerstein & Pribyl, O'Reilly, Shroff Publishers & Distributors Pvt. Ltd. **8.** Manual of RDBMS
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 3rd Semester

Elective Paper

Course-3052: Stochastic Process

Course Code	3052
Course Title	Stochastic Processes
Credit	4
Teaching per Week	4
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	2019-20
Purpose of Course	Students are expected to choose appropriate stochastic process model(s) for a given research in applied problem and apply the theory to model real phenomena and solve several problems concerning random behaviour in different fields of applied science.
Course Objective	To develop an ability to analyse and apply some basic stochastic processes for solving real life situations.
Course Outcomes	After completing this course, the students will be able to: CO1: Understand the stochastic processes, Markov chains, Transition probability matrix and various types of states. CO2: Explain Random walk, Gambler ruins problem and apply Poisson process in real life situations. CO3: Formulate and solve problems which involve setting up stochastic models. CO4: Derive different queuing models applicable to real life situation CO5: Understand renewal theory and branching processes with applications.
Mapping between COs with PSOs	
Pre-requisite	Basic knowledge of calculus and probability
Course Content	**UNIT I:** • Stochastic Process, Markov Process and Markov chain. • Markov chain with finite and countable state space, limiting behavior of n-step transition probabilities, stationary process. **UNIT II:** • Markov Processes in continuous time (Poisson Process, Birth and death processes), Classification of states of a Markov chain. • Random walks, Gambler's ruin.

	UNIT III: • Queueing Theory: Definition, Characteristics of a queueing system, Poisson Process and Exponential distribution, Classification of queues, Birth model, Death model, Birth death model. **UNIT IV:** • Detailed study of M/M/1 queueing models. **UNIT V:** • Detailed study of M/M/C queueing models.
Reference Books	1. Karlin S.: "A First Course in Stochastic Processes"; Academic Press. 2. Parzen E.: "Stochastic Processes"; Holden-Day. 3. Feller W.: "An Introduction to Probability Theory and its Application"; Vol.I, 3rd Ed., John Wiley. 4. Hoel P.G., Port S. C. and Stone C. J.: "Introduction to Stochastic Processes"; Houghton Mifflin Co., Bosten. 5. K. Swarup, Gupta P.K. and Man Mohan: "Operations Research"; S. Chand & Co., New Delhi. 6. Sharma S.D.: "Operations Research"; Kedar Nath Ram Nath & Co. Publishers,
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 3rd Semester

Elective Paper

Course-3053: Mathematical Economics

<table>
<tr><td>Course Code</td><td>3053</td></tr>
<tr><td>Course Title</td><td>Mathematical Economics</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>2019-20</td></tr>
<tr><td>Purpose of Course</td><td>Students are expected to choose appropriate economic model(s) for a given research in applied problem and apply the theory to model real phenomena and solve several problems.</td></tr>
<tr><td>Course Objective</td><td>To learn and develop an analytic approach to deal with financial data.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, the students will be able to:
CO1: Understand the concept of theory of consumer behaviour with different types of demand and their functions.
CO2: Understand the concept of theory of firm with different function and properties
CO3: Apply the concept of market equilibrium
CO4: Understand the nature of input-output analysis in open and closed system in economics.
CO5: Understand the concept of different Growth models in economy.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table><tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr><tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>Pre-requisite</td><td>Basics of linear algebra and calculus</td></tr>
<tr><td>Course Content</td><td>UNIT I:
• Theory of Consumer Behaviour:
Meaning of Utility, Utility function, Indifference curve, Rate of Commodity substitution, Utility maximization, Choice of utility index, simple demand function, compensated demand function, demand curves, Elasticity of demand, price elasticity of demand, income elasticity of demand, cross elasticity of demand, Total revenue, marginal revenue, average revenue, and their relationship
UNIT II:
• Theory of the firm:
Production function, Product curves, Marginal product, Isoquents, Elasticity of substitution, Homogeneous production function, properties of homogeneous production function, Constant elasticity</td></tr>
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	of substitution (CES) production function, Joint products, properties of Cobb-Douglas production function, cost function, cost elasticity of a commodity **UNIT III:** • Market equilibrium: Perfect competitive market, Imperfect competitive market, Monopoly, profit maximization of a monopolist, price discrimination, market discriminations, perfect discrimination, Applications of monopoly, examples. Duopoly, duopoly for homogeneous product and their applications, examples. **UNIT IV:** • Input – Output Analysis : Leontief's static models for inter industry relations. The Leontief's open and closed system. • Growth Models : Classical and Keynesian simple income determination models. Concepts of multipliers and accelerator. Harrod-Domar model, Hicks-Samuelson model, Solow's Growth model. Mahalanobis two and four sector models.
Reference Books	1. Henderson and Quant: Microeconomic theory, McGraw Hill 2. Karmel P.H. : "Applied Statistics for Economics". 3. Sen A.K. : Growth Economics : Penguin Modern Economic Reading Edition. 4. Pillai S. : Economic & Business Statistics; Progressive Corporation Pvt. Ltd. 5. Mukhopadhyay P. : Applied Statistics; New Central Book Agency (P) Ltd. 6. Gupta S.C. and Kapoor V.K. : Fundamentals of Applied Statistics; Sultan Chand & Sons.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course: 3054 Statistical quality control and Reliability

<table>
<tr><td>Course Code</td><td>3054</td></tr>
<tr><td>Course Title</td><td>Statistical quality control and Reliability</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4 Hrs</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Class work, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>June 2019</td></tr>
<tr><td>Purpose of Course</td><td>The purpose of the course is to develop scientific view to analyze the industrial data about specific perspective. • To learn the statistical quality control techniques used in industries such as control charts, acceptance sampling plans etc. • To learn some advanced control charts, capability indices and the concept of six-sigma.</td></tr>
<tr><td>Course Objective</td><td>To make students acquainted with concepts quality management.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, students will be able to:
CO1: Understand basic of production process monitoring and apply concept of control charts on it.
CO2: Apply the acceptance and continuous sampling plans in production process.
CO3: Know and apply the concept of weighted control charts, six sigma, SO: 9000 series standards and Taguchi design.
CO4: Understand the concepts of quality control, chance and assignable causes of variation, control charts for variables and attributes, producer’s and consumer’s risk - Acceptance sampling plans.
CO5: Get idea of important lifetime distributions such as for exponential, Weibull, gamma and lognormal distributions.
CO6: Use of estimation in the reliability analysis.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
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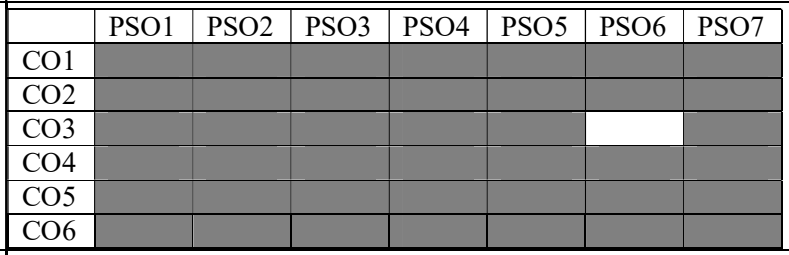
<tr><td>Pre-requisite</td><td>Basics of quality control management and reliability analysis</td></tr>
<tr><td>Course Content</td><td>UNIT I:
• The meaning of Quality & Quality improvement
• Introduction of statistical quality control
• Statistical process control
➢ Introduction
➢ Measure of location and variability
➢ Process of control charts for variables & attribute
➢ Process of control limits
➢ Out of control criteria
• Process and measurement system capability analysis</td></tr>
</table>

	UNIT **II:** • Cumulative sum chart • Statistical product control ➢ Introduction ➢ Standard plans for attributes ➢ Plan for acceptance sampling by measurement. **UNIT III:** • Total Quality Management ➢ Meaning and important concepts ➢ Importance of quality management ➢ Total quality management models ➢ Six sigma and Quality management ➢ Kaizen process ➢ Strategic quality planning and total quality management ➢ The cost of quality ➢ Productivity ➢ ISO 9001. **UNIT IV:** • Reliability ➢ Basic concepts and distributions for product life, failure rate. ➢ Hazard function, Reliability function for Exponential, Normal, Lognormal, Weibull and Gamma Distributions. ➢ Analysis of Complete Data. ➢ Linear analysis and maximum likelihood analysis of censored data for exponential distribution only. ➢ System reliability. ➢ Introduction of Bayes Methods in Reliability. ➢ Accelerated life testing
Reference Books	1. Hopper A.G.: "Basic Statistical Quality Control"; McGraw Hill, London. 2. Gupta R.C.: "Statistical Quality Control"; Khanna Publishers, New Delhi. 3. Ryan T.P.: "Statistical Methods for Quality Improvement"; John Wiley & Sons. 4. Omachonu V.K. and Ross J.E.: "Principles of Total Quality"; S.Chand & Co., New Delhi. 12 5. Sinha S.K.: "Reliability and Life Testing"; Wiley Eastern Ltd., New Delhi. 6. Bazovksy I.: "Reliability Theory and Practice"; Prentice Hall International Series in Engineering. 7. Grant E. L. and Leavenworth R.: "Statistical Quality Control"; Tata Mc Graw Hill Publishing Co. Ltd., New Delhi. 8. Irving W.B.: "Elementary Statistical Quality Control"; Marcel Dekker, Inc., New York. 9. Douglas C. Montgomery: Introduction to statistical quality control
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment

Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 3rd Semester

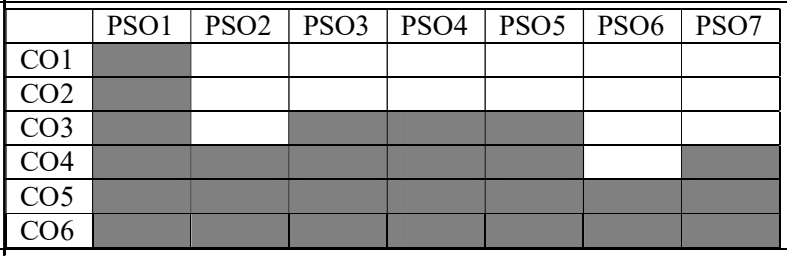
Course-306: Practical paper- III

Course Code	306
Course Title	Practical paper- III
Credit	4
Teaching per Week	8
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	2019-20
Purpose of Course	The purpose of this course is to introduce practical based on theory papers using statistical software (SPSS and R) and MS office tools excel
Course Objective	To learn analysis of various kinds of data using software to help the students understand how to go around with the computing part of some of the theoretical aspects.
Course Outcomes	After successful completion of this course, student will be able to: CO1: Solve problem related to testing of hypothesis by excel and software CO2: Apply different econometrics model to real life situations run by excel and software. CO3: Apply Operations research technique to real life problems. CO4: Use statistical packages in different types of data. CO5: Handel and process the data using statistical packages CO6: Apply Data mining technique in large scale data CO7: Draw controls charts and apply acceptance sampling plans in industry point of view
Mapping between COs with PSOs	
Pre-requisite	Students should be aware about Parametric Test, Regression models, Operations Research Technique, basic about statistical software SPSS and R, Data Mining tools etc.
Course Content	Based on theory paper 301 to 304 and elective papers (3051 to 3054)
Reference Books	Reference book mention in theory paper 301 to 304 and elective papers (3051 to 3054)
Teaching Methodology	Classwork, Discussion, Lab work, self-study, practical session, Live demo, hands on training.
Evaluation Method	30% Internal assessment based on class attendance, journal, internal practical examination, VIVA etc. 70% External based on semester

	end University examination.

M. Sc. Statistics 3rd Semester

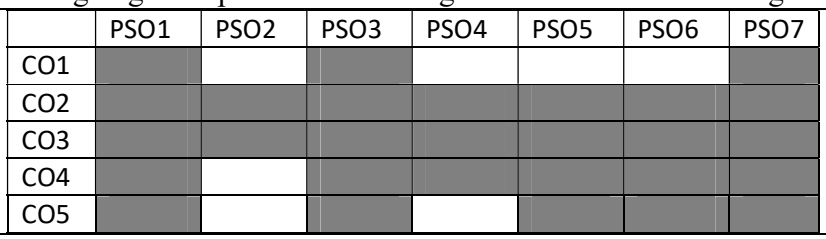
Course-401: Decision Theory

Course Code	401
Course Title	Decision Theory
Credit	4
Teaching per Week	4
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	1970
Purpose of Course	To make students understand decision theory based on Bayesian probability i.e., making rational decisions against multiple criteria and testing of hypotheses using data sets which do not have any parametric information.
Course Objective	The main objective of this course is to provide the detailed knowledge of statistical inference under Bayesian framework and Non-Parametric inference.
Course Outcomes	After successful completion of this course, student will be able to: **CO1:** Identifying and dealing with the situations of decision making under risk and uncertainty **CO2:** Understand decision problem, loss function, risk function and decision rules, their admissibility and completeness **CO3:** use of different decision rules under uncertainty and risk. **CO4:** Obtaining best decision rules using different types of prior, posterior distributions and loss functions **CO5:** Understand the applicability of different nonparametric statistical tests for one, two (paired as well as unpaired) and more than two populations. **CO6:** Solve hypothesis testing problems where the conditions for the traditional parametric inferential techniques are not fulfilled.
Mapping between COs with PSOs	
Pre-requisite	Detailed knowledge of Probability theory, Estimation Theory and Probability distribution.
Course Content	**UNIT I:** • **Review of basic elements of statistical decision problem:** Various inference problems viewed as decision problems. **UNIT II:** • **Introduction to Decision Analysis:** Pay-off table for decisions and discussion of decision criteria,

	Decision trees. **UNIT III:** • **Main theorems of Decision Theory:** Natural ordering of decision rules. Complete and essentially complete classes of decision rules. Admissibility of Bayes rules. Existence of Bayes decision rules and of Minimax complete class when parameter space is finite and the risk set is closed and bounded from below. **UNIT IV:** • **Invariant decision problems** Invariant decision rules, Admissible, minimax invariant rules. **UNIT V:** • **Non-Parametric Methods for Testing of hypotheses:** ➢ Tests for one sample ➢ Tests for two related samples ➢ Tests for two independent samples ➢ Tests for k related samples ➢ Tests for k independent samples ➢ Tests of significance of measures of correlation
Reference Books	1. Berger J.O. : "Statistical Decision Theory"; Springer –Verlag Pub. Co., New York. 2. Gibbons J.D. : "Nonparametric Statistical Inference"; McGraw Hills. 3. Ferguson T.S. : "Mathematical Statistics"; Academic Press. 4. Kendall M.G. and Stuart A.: "The Advanced Theory of Statistics"; Vol. 2., Ed. IV, Charles and Griffin. 5. Mood A.M., Grabill F. and Boes D.C. : "Introduction to the Theory of Statistics"; McGraw Hills, International Student Ed. III. 6. Sedney Seigal : "Nonparametric Methods for Behavioral Sciences"; McGraw Hill. 7. Gibbons J.D. and Pratt J.W. : "Concepts of Nonparametric Theory"; Springer-Verlag. 8. Daniel W.W. : "Applied Nonparametric Statistics"; PWS-KENT publishing Co., Boston. 9. Conover W.J. : "Practical Nonparametrics"; John Wiley. 10. Wald A. : "Sequential Analysis"; Wiley 11. Hettmansperger, T.P. (1984). Statistical inference Based on Ranks, John Wiley & Sons. 12. Randles, R.H. and Wolfe, D.A. (1979). Introduction to the Theory of Nonparametric Statistics, John Wiley & Sons. 13. Rohatgi, V.K. and Saleh, A.K. Md. E. (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley & Sons.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment

Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course: 402: DESIGN OF EXPERIMENTS

Course Code	**402**
Course Title	**DESIGN OF EXPERIMENTS**
Credit	4
Teaching per Week	4 Hrs
Minimum weeks per Semester	15 (Including Class work, examination, preparation, holidays etc.)
Effective From	June 2020
Purpose of Course	The purpose of the course is to learn the applications of different designs in agriculture, medical and industry.
Course Objective	To make students acquainted with various techniques of design of experiment.
Course Outcomes	After completing this course, students will be able to: CO1: Understand the concept of design and conduct experiments efficiently and effectively CO2: Analyze the resulting data to obtain objective conclusions. Both design and statistical analysis issues are discussed. CO3: Develop the concept of various designs CRD, RBD, LSD, BIBD, Factorial and Confounded designs. CO4: Understand the difference between various designs of experiments. CO5: Particular attention will be paid to understanding the process of designing an experiment including factorial and confounding designs.
Mapping between COs with PSOs	
Pre-requisite	Basic concept of experimental designs and drawing inferences
Course Content	**UNIT I:** • Concept and history of Design of experiments. • The need for Designed experiments. • Elementary ideas of blocking and randomized block design. • Elementary idea of treatment structure and Basic principles of Design of experiments • Concept of complete and incomplete block designs. Completely Randomized Design(CRD), Randomized Block Design(RBD), Latin square design(LSD), their analysis with applications. Missing plot technique for RBD, LSD with their applications. UNIT **II:** • Concept of BIBD and its properties. Intra block analysis of BIBD, construction of BIBD, Missing plot technique for BIBD. **UNIT III:** • Analysis of Covariance: Analysis of covariance for CRD, RBD and LSD, Youden square design, Cross over design, split-plot designs. **UNIT IV:** • Factorial Experiments : Characterization of experiments, factorial experiments, factorial experiments with factors at two levels, grouping for interaction contrasts, confounding, confounding in more

	than two blocks, experiments with factors at three levels each, analysis of factorial experiments.
Reference Books	1. Montgomery, D. C. (1997): "Design and Analysis of Experiments"; 4th edition, John Wiley & Sons, New York 2. Montgomery, D. C. (2006): "Design and Analysis of Experiments"; 5th Ed, Wiley (India), **ISBN:** 812651048X, **ISBN-13:** 9788126510481, 978-8126510481 3. R. Mead. (1990): "The Design of Experiments: Statistical Principles for Practical Application"; Cambridge Uni. Press. ISBN-10: 0521287626, ISBN-13: 978-0521287623 4. Cochran W.G. and Cox G.M. (2003): "Experimental Designs"; 2nd Edition, John Wiley (wie) **ISBN:** 9971513110, **ISBN-13:** 9789971513115, 978-9971513115. 5. Cochran W.G. and Cox G.M. (1957): "Experimental Designs"; 2nd Edition, John Wiley & Sons Inc., New York, **ISBN:** 0471162035, **ISBN-13:** 9780471162032 6. Das, M.N. and Giri, N.C. (1986). Design and Analysis of Experiments. Wiley Eastern Ltd., New Delhi. 7. Das M.N. and Giri N.C.(1999) : "Design and Analysis of Experiments"; 2nd Edition, New Age International Publishers Ltd, **ISBN:** 0852269145, **ISBN-13:** 9780852269145. 8. Federer W.T. (1993) : "Statistical Design And Analysis For Intercropping Experiments"; Springer-verlag, **ISBN:** 0387979239, **ISBN-13:** 9780387979236, 978-0387979236 9. Federer, W. T. (1955): "Experimental Design: Theory and Application"; The Macmillan Co., New York. 10. Klaus Hinkelmann, Kempthorne Oscar (2005): "Design and Analysis of Experiments"; Wiley-interscience, **ISBN:** 0471551775, **ISBN-13:** 9780471551775 11. Kempthorne, O. (1952), The Design and Analysis of Experiments, John Wiley & Sons, New York 12. Fisher R. A. (2005): "Statistical Methods for Research Workers"; Cosmo Publications, **ISBN:** 8130701332, **ISBN-13:** 9788130701332, 978-8130701332 13. Panse, V.G. and Sukhatme, P.V. (1978): "Statistical methods for agricultural workers"; ICAR, New Delhi.
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 3rd Semester

Course-403: Operations Research-II

<table>
<tr><td>Course Code</td><td>403</td></tr>
<tr><td>Course Title</td><td>Operations Research II</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>1970</td></tr>
<tr><td>Purpose of Course</td><td>The purpose of this course is to Study Operations research (OR) which is an analytical method of problem-solving and decision-making that is useful in the management of organizations with the help of mathematical and statistical techniques</td></tr>
<tr><td>Course Objective</td><td>To develop the optimization techniques that will be useful in the personal and professional life.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, the students will be able to:
CO1: Understand basic concept of sensitivity analysis with changes in objective function, vector b and matrix A. Also discuss the cases for addition and deletion of variable and constrains with example
CO2: Cconstruct integer programming problems with different types to discuss the solution techniques.
CO3: Select the best sequence through different machine to different jobs to minimize time
CO4: Understand the concept of PERT/CPM and their real life application
CO5: Become aware of the concept of replacement problems with fixed money and variable money effect. Comparison of group and individual policy
CO6: Explain the concept of Goal programming problem, their formulation method and example</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table><tr><th></th><th>PSO1</th><th>PSO2</th><th>PSO3</th><th>PSO4</th><th>PSO5</th><th>PSO6</th><th>PSO7</th></tr><tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>Pre-requisite</td><td>Concept of liner algebra, basic mathematical operations</td></tr>
<tr><td>Course Content</td><td>UNIT I:
Sensitivity Analysis:
Basic concepts
Changes in the coefficient of objective function
Changes in the components of vector b and of Matrix A
Addition / Deletion of variable in the problem</td></tr>
</table>

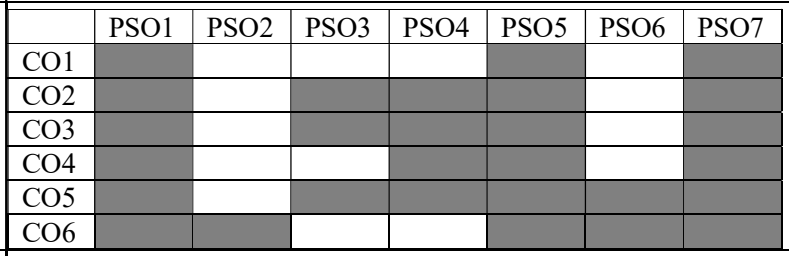
	➢ Addition / Deletion of constraint in the problem **UNIT II:** • Integer Programming: ➢ Introduction ➢ All and mixed integer programming (IPP) problems ➢ Gomory's al1-IPP algorithm ➢ The branch and bound technique ➢ Zero - one programming • Sequencing Problems: ➢ Definition, Notations and Assumptions ➢ Solution of sequencing problem. ➢ Problems with n-jobs and 2-machincs ➢ Problems with n-jobs and 3-machines ➢ Problems with 2-jobs and m-machines **UNIT III:** • PERT / CPM: ➢ Basic concepts . ➢ Construction and Time Calculation of the Network ➢ Determination of Float and of the Critical Path ➢ Crashing a Project ➢ Scheduling a Project ➢ Resource Analysis and Allocation ➢ Application of PERT/ CPM **UNIT IV:** • Replacement Theory: ➢ Types of Replacement Problem ➢ Replacement of Items that Deteriorate ➢ Replacement of Items that fails completely and that of Staff • Goal Programming: ➢ Definitions and Concepts ➢ Formulation of Goal Programming Problem (GPP) ➢ Solution of GPP by Graphical and Extended Simplex Methods
Reference Books	1. K. Swarup, Gupta P.K. and Man Mohan : "Operations Research"; S.Chand & Co.,New Delhi. 2. G. Hadley : "Linear Programming"; Oxford & IBH Pub. Co 3. Murthy K.G. : "Linear and Nonlinear Programming". 4. Kasana H.S. and Kumar K.D. : "Introductory Operations Research"; Springer. 5. Kapoor V.K. : "Operations Research"; S.Chand & Co.,New Delhi. 6. Sharma S.D. : "Operations Research"; Kedar Nath Ram Nath & Co.

	Publishers, Meerut.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 3rd Semester

Elective Paper

Course-4041: Economic & Business Statistics

Course Code	4041
Course Title	Economic & Business Statistics
Credit	4
Teaching per Week	4
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	2019-20
Purpose of Course	The paper provides the students exposure to different time series models, frame work of various index numbers and aware about the demand analysis technique
Course Objective	To learn and develop statistical view to understand the time series data, index numbers and demand analysis.
Course Outcomes	After completing this course, the students will be able to: CO1: Understand the concept of index numbers with their property CO2: Aware different types of index numbers useful in real life. CO3: Understand the purpose of demand analysis for different types of data and method for studying this. CO4: Understand the concept of time series analysis with components and its methods. CO5: Derive different time series models using Box-Jenkins methodology, remove trend and seasonality using different methods to convert the time series into stationary. CO6: Check and validate models with its residual analysis and diagnostic checking.
Mapping between COs with PSOs	
Pre-requisite	Basics of time series, Index numbers and Demand Analysis
Course Content	**UNIT I:** • Index Numbers: Price, Quantity and Value indices. Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers, Chain Index Number. Consumer Price Index, Wholesale Price Index and Index of Industrial Production – Construction of index numbers and uses. Cost of Living Index Number and Various Official Index Numbers, HDI (Human Development Index) **UNIT II:**

	• Demand Analysis : Concept related to demand and supply, price elasticities of demand and supply, Methods of determining demand and supply curves for cross section data and time series data, Leontief's method, Pigou's Method, Engels Curves, Pareto's Law of Income Distribution. **UNIT III:** • Time Series Analysis: Definition and importance of time series analysis. Components of a Time series. Different methods for determination of trend, Methods for elimination of seasonal components. Determination of cyclic components. Variate difference method and their merits and demerits. **UNIT IV:** • Stationary Time series, Box-Jenkins Models, Introduction to Autoregressive (AR) Models, Moving Average (MA) Models, Mixed Autoregressive Moving Average (ARMA) Models.Autoregressive Integrated Moving Average (ARIMA) Models. Properties of these models. Forecasting Techniques, Seasonal ARIMA model, Introduction to conditional Heteroscedasticity model; Volatility models, ARCH model, GARCH model, properties, estimation and forecasting of these models.
Reference Books	1. Allen R. G. D. (1975). Index Numbers in Theory and Practice, Macmillan. 2. Kendall M. : "Time Series"; Charles Griffin and Company. 3. Box and Jenkins : Time Series Analysis : Forecasting and Control; Holden Day Pub. 4. Chatfield C. : The Analysis of Time Series : Theory and Practice; Chapman and Hall. 5. Waller Vancuels : Applied Time Series and Box Jenkins Models. 6. Karmel P.H. : "Applied Statistics for Economics". 7. Sen A.K. : Growth Economics : Penguin Modern Economic Reading Edition. 8. Pillai S. : Economic & Business Statistics; Progressive Corporation Pvt. Ltd. 9. Mukhopadhyay P. : Applied Statistics; New Central Book Agency (P) Ltd. 10. Gupta S.C. and Kapoor V.K. : Fundamentals of Applied Statistics; Sultan Chand & Sons. 11. Anderson. T. W. (1971). The Statistical Analysis of Time Series Wiley, N. Y. 12. Montgemory, D. C. Johnson L. A (1990) Forecasting and Time Series Analysis, McGraw Hill.

	13. Brockwell, P. J. and Davis R. A. (2006) Time Series: Theory and Methods (Second Edition) Springer-Verlag.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

well as practical knowledge of analyzing the data coming out from share market, Business analytics, sports, medical science, and public health and so on.

M. Sc. Statistics 3rd Semester

Elective Paper

Course-4042: Official Statistics

<table>
<tr><td>Course Code</td><td>4042</td></tr>
<tr><td>Course Title</td><td>Official Statistics</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Class work, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>2019-20</td></tr>
<tr><td>Purpose of Course</td><td>To understand official statistics and its role in framing policies in Economics and Business and the system of official statistics in India</td></tr>
<tr><td>Course Objective</td><td>To make students competent in theories and practices of official statistics.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, students will be able to:

CO1: Understand Indian Statistical systems, its role, functions and activities i.e. understand the role of MoSPI, CSO, NSSO, National Statistical Commission.
CO2: Appreciate and use techniques of quantitative analysis in social work research
CO3: Discuss the scope and contents of population census of India.
CO4: Identify Statistics related to industries, foreign trade, balance of payment, cost of living inflation, educational and social statistics etc.
CO5 : Understand economic development and national income estimation
CO6: Discuss the measures of inequality in income and measures of incidence and intensity.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><th></th><th>PSO1</th><th>PSO2</th><th>PSO3</th><th>PSO4</th><th>PSO5</th><th>PSO6</th><th>PSO7</th></tr>
<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Pre-requisite</td><td></td></tr>
<tr><td>Course Content</td><td>UNIT I:
• Statistical System in India: Central and State Government Organizations, Functions of Central Statistical Organization (CSO), National Sample Survey Organization (NSSO).

UNIT II:
• Official statistics: Meaning, methods of collection, limitations and reliability. Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications -</td></tr>
</table>

	Banking and finance. **UNIT III:** • National Income – Measures of national income - Income, expenditure and production approaches - Applications in various sectors in India. **UNIT IV:** • Measurement of income inequality: Lorenz curves, Application of Pareto and Lognormal as income distribution. • Organization of large scale sample surveys. General and special data dissemination systems.
Reference Books	1. Bhaduri, A. (1990). Macroeconomics: The Dynamics of Commodity Production, Macmillan India Limited, New Delhi. 2. Branson, W. H. (1992). Macroeconomic Theory and Policy, Third Edition, Harper Collins Publishers India (P) Ltd., New Delhi. 3. C. S. O. (1990). Basic Statistics Relating to the Indian Economy. 4. C.S.O. (1995). Statistical System in India. 5. C. S. O. (1999). Guide to Official Statistics. 6. C. S. O. (2016). Guide to Official Statistics. 7. Goon A. M., Gupta M. K., and Dasgupta. B. (2001), Fundamentals of Statistics, Vol. 2, World Press, India. 8. Mukhopadhyay P. (2011). Applied Statistics, Second Edition, Books & Allied Ltd, India. 9. Asthana, B.N. and Srivastava, S.S.(1984): Applied Statistics of India, Chaitanya Publishing House, Allahabad.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 3rd Semester

Elective Paper

Course-4043: Bio-Statistics & Clinical Research

<table>
<tr><td>Course Code</td><td>4043</td></tr>
<tr><td>Course Title</td><td>Bio-Statistics & Clinical Research</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Class work, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>2019-20</td></tr>
<tr><td>Purpose of Course</td><td>The purpose of this course is to train students to utilise their knowledge of Statistics for the research related to health / biological/ medical fields.</td></tr>
<tr><td>Course Objective</td><td>Biostatistics is one area of Applied statistics that deals with drawing statistical inference from the research data related generated from planned experiments/trails for health / biological/ medical fields.</td></tr>
<tr><td>Course Outcomes</td><td>After successful completion of this course, student will be able to:
CO1. Plan study design and do data analysis for the health / biological/ medical sciences.
CO2. Understand how the basic principles of probability are useful for biostatistics.
CO3. Do survival Analysis/ failure analysis for the health / biological/ medical sciences.
CO4. Estimating the risk of one type of failure after removing others
CO5. Evaluate, from simple datasets, evidence for linkage disequilibrium and disease associations using basic association tests
CO6: planning, analysing and interpreting statistical out puts of different phases of clinical trials, including deciding sample size.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><th></th><th>PSO1</th><th>PSO2</th><th>PSO3</th><th>PSO4</th><th>PSO5</th><th>PSO6</th><th>PSO7</th></tr>
<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Pre-requisite</td><td>Probability theory , estimation theory, Testing of hypotheses, design of experiments, Multivariate analysis</td></tr>
<tr><td>Course Content</td><td>UNIT I:
• Introduction to Bio-statistics, Sources of medical uncertainties, managing medical uncertainties. Applications of Bio-statistics as a science.
• Clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials. Data management: data</td></tr>
</table>

	definitions, data collection systems for good clinical practice, protocol definition. **UNIT II:** • Design of clinical trials : parallel vs. cross-over designs, cross-sectional vs. longitude designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of Phase III trials with sequential stopping, design of bioequivalence trials. **UNIT III:** • Reporting and analysis: analysis of categorical outcomes from Phase I - III trials, analysis of survival data from clinical trials. Interim analysis method, motivating intent- to-treat analysis. **UNIT IV:** • Determining sample size. Surrogate endpoints: selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data.
Reference Books	1. Prem Narayan, Bhatia & Malhotra (1979): Handbook of Statistical Genetics, IASRI, New Delhi. 2. Jain, J.R. (1982): Statistical techniques in quantitative genetics, Tata Mcgraw Hill. 3. Govindarajulu, Z. and Kargar, S. (2000): Statistical Techniques in Bioassay. 4. Finney, D.J (1971): Statistical Method In Bioassay, Griffin. 5. Finney, D.J (1971): Probit Analysis (3rd Edition), Griffin. 6. Weatherile, G.B. (1966): Sequential Methods in Statistics, Griffin. 7. Piantadosi, S. (1977): Clinical: A Methodologic Perspective. Wiley and Sons. 8. Jennison, C. and Turnbull, B.W (1999): Group Sequential Methods with Applications to Clinical Trials, CRC Press. 9. Flesis, J.L (1989): The Design and Analysis of Clinical Experiments. Wileyand Sons. 10. Marubeni, E. and Valsechhi, M.G (1994): Analyzing Survival Data From Clinical Trials and Observational Studies. Wiley and Sons. 11. Friendman,L.M., Furbery, C.D. and Demets, D.L.(1998): " Fundamental of clinical Trials " Springer Publication,3rd ed., Springer. 12. Duolaowang, A. B. (2006): Clinical Trials A Practical Guide to Design, Analysis, and Reporting, Published by Remedica, USA 13. Indrayan and L. Satyanarayana : Biostatistics for medical, nursing and pharmacy students, Eastern Economy Edition, Prentice hall

	India, ISBN 81-203-3054. 14. B. K. Mahajan: Method in Biostatistics for medical students and research work, Sixth edition, Jaypee Brothers medical publisher LTD. ISBN 81-7179-520-X.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 3rd Semester

Elective Paper

Course-4044: Statistical Simulation

<table>
<tr><td>Course Code</td><td>4044</td></tr>
<tr><td>Course Title</td><td>Statistical Simulation</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>2019-20</td></tr>
<tr><td>Purpose of Course</td><td>Students are expected to choose proper models for a given research in applied problem and apply the theory to model real phenomena and solve several problems concerning random behaviour in different fields of applied science.</td></tr>
<tr><td>Course Objective</td><td>To develop an ability to analyse run simulation model to real world problem.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, the students will be able to:
CO1: Generate random numbers
CO2:Generate random numbers from probability distribution
CO3: Use simulation for statistical inference
CO4: Apply Jackknife and Bootstrap methods in different types of populations</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><th></th><th>PSO1</th><th>PSO2</th><th>PSO3</th><th>PSO4</th><th>PSO5</th><th>PSO6</th><th>PSO7</th></tr>
<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Pre-requisite</td><td>Probability Distributions, Sampling Theory and optimization technique and Statistical Inference</td></tr>
<tr><td>Course Content</td><td>UNIT I:
• Statistic simulations: generating random variables, simulating normal, gamma and beta random variables. Comparison of algorithms to generate random variables. Generating random variables from failure rates.

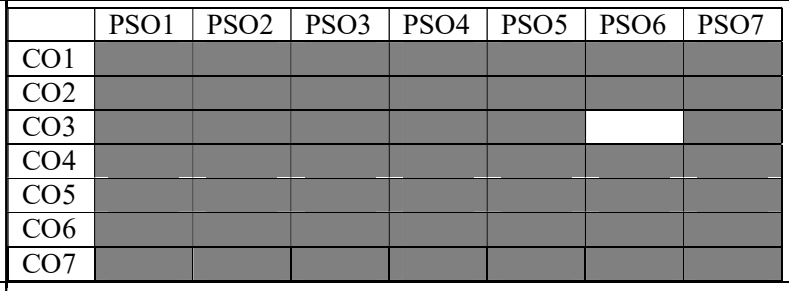
UNIT II:
• Simulating multivariate distributions, MCMC methods and Gibbs sampler, simulating random fields, simulating stochastic process. Variance reduction technique: importance sampling for integration, control variates and antithetic variables.

UNIT III:
• Simulating a non-homogeneous Poisson process, Optimization using Monte Carlo methods, simulated annealing for optimization.</td></tr>
</table>

	Solving differential equations by Monte Carlo methods. **UNIT IV:** • Jackknife and Bootstrap: Bootstrap methods, re-sampling paradigms, bias and standard errors, Bootstrapping for estimation of sampling distribution. Confidence intervals, variance stabilizing transformation, bootstrapping in regression and sampling from finite populations.
Reference Books	1. Fishman, G.S. (1996) Mante Carlo: Concepts, Algorithms and Applications. (Springer). 2. Rubinstein, R.Y. (1981); Simulation and the Monte Carlo Method. (Wiley). 3. Ripley, B.D. (1987) Stochastic Simulations (Wiley). 4. Ross, S. M. (2002) Simulation (Third Edition) (Academic). 5. Efron,B. and Tibshirani. R.J. (1993); An introduction to the Bootstrap. 6. Davison, A.C. and Hinkley,D.V. (1997) Bootstrap methods and their applications (Chapman and Hall). 7. Sho.J and Tu,D (1995); The Jackknife and the Bootstrap. Springer Verlag.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

M. Sc. Statistics 4th Semester

Course-405: Practical Paper-IV

Course Code	405
Course Title	Practical Paper IV
Credit	4
Teaching per Week	8
Minimum weeks per Semester	15 (Including Class work, examination, preparation, holidays etc.)
Effective From	2019-20
Purpose of Course	The purpose of this course is to introduce practical based on theory papers using statistical software (SPSS and R) and MS office tools excel
Course Objective	To learn analysis of various kinds of data using software to help the students understand how to go around with the computing part of some of the theoretical aspects.
Course Outcomes	After successful completion of this course, student will be able to: CO1: Solve problem related to Non-parametric test and decision theory CO2: Apply different design to various agriculture experiment CO3: Apply Operations research technique to real life problems CO4: Fit a time series models to real data using software CO5: Solve index number and demand analysis problems by excel CO6: Apply different statistical technique to solve clinical research problem using software CO7: Perform simulation technique to given data set using software
Mapping between COs with PSOs	
Pre-requisite	Students should be aware about basic ofNon-parametric test, different types of Designs, Operations Research technique, Time Series models, Index numbers, Demand Analysis, Official Statistics, Basics of clinical trials and simulation
Course Content	Based on theory paper 401 to 403 and elective papers (4041 to 4044)
Reference Books	Reference book mention in theory paper 401 to 403 and elective papers (4041 to 4044)
Teaching Methodology	Class work, Discussion, Lab work, self-study, practical session, Live demo, hands on training.
Evaluation Method	30% Internal assessment based on class attendance, journal, internal

	practical examination, VIVA etc. 70% External based on semester end University examination.

M. Sc. Statistics 3rd Semester

Course: Project

<table>
<tr><td>Course Code</td><td></td></tr>
<tr><td>Course Title</td><td>Project</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>4</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>2008</td></tr>
<tr><td>Purpose of Course</td><td>The purpose of this course is to train students for any kind and every kind of data analysis and to interpreter finding in a laymen’s language for easy understanding and implementation of it. .</td></tr>
<tr><td>Course Objective</td><td>To train students to be industry ready to suggest best possible solution of a problem using their knowledge and expertise of statistics.</td></tr>
<tr><td>Course Outcomes</td><td>After completing this course, students will be able to:
CO1: Students will be well trained for planning, execution of a study
CO2: collect data, data validation, deciding appropriate statistical techniques for statistical analysis
CO3: To analyse the data using appropriate statistical packages/ tools,
CO4: Interpreting the statistical out put meaningfully and easy to understand for applicability.
CO5: To contribute significantly in planing, development and research of every area where statistics plays an important role.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
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<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Pre-requisite</td><td>All the theory as well as practical papers taught during 4 semesters</td></tr>
<tr><td>Course Content</td><td>Students may start preliminary work related to their project after second semester (Project review of earlier done project) and actual time for project is 10 weeks during 4th semester, that includes Identification/finalising a problem to work on, literature review related to that, data collection, data validation, data representation, analysis, interpretation , report writing and final presentation.</td></tr>
<tr><td>Reference Books</td><td>All the references books suggested for different papers during 4 semesters.</td></tr>
<tr><td>Teaching Methodology</td><td>Class work, Discussion, Self-Study, Seminars, industry visit and presentations</td></tr>
<tr><td>Evaluation Method</td><td>30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination</td></tr>
</table>