SYLLABI AND SCHEME OF EXAMINATIONS FOR M.Sc.(Statistics)

(Based on Curriculum and Credit Framework for PG Programs under NEP-2020)

WITH EFFECT FROM THE SESSION 2024-25

MAHARSHI DAYANAND UNIVERSITY ROHTAK (HARYANA)

Structure for 2 year Post Graduate Programme

	Semester	Discipline-Specific Courses (DSC)	Skill Enhancement Courses (SEC) / Vocational Courses (VOC)/ Internship	Research thesis/project	Total Credits
	First year of 2 Year PG program (NHEQF Level 6)				
	I	DSC 1 @ 4 credits DSC 2 @ 4 credits DSC 3 @ 4 credits DSC 4 @ 4 credits DSC 5 @ 4 credits	SEC1/VOC 1/Internship 1 @ 4 credits	---	24
	II	DSC 6 @ 4 credits DSC 7 @ 4 credits DSC 8 @ 4 credits DSC 9 @ 4 credits DSC 10 @ 4 credits	SEC2/VOC2/Internship 2 @ 4 credits	---	24
Students who exit after first year on completion of 48 credits will be awarded PG Diploma in concerned discipline					
Second year of two year PG program (NHEQF Level 6.5) (STUDENT SHOULD SELECT ANY ONE OPTION FOR THE SECOND YEAR OF 2 YEAR PG PROGRAM)					
Only Course Work					
Option 1	III	DSC 11 @ 4 credits DSC 12 @ 4 credits DSC 13 @ 4 credits DSC 14 @ 4 credits DSC 15 @ 4 credits	SEC 3/Internship 3/ Project Work 1 @ 4 credits	---	24
	IV	DSC 16 @ 4 credits DSC 17 @ 4 credits DSC18 @ 4 credits DSC19 @ 4 credits DSC20 @ 4 credits	SEC4/Internship 4/ Project Work 2 @ 4 credits	---	24
Course work and Research					
Option 2	III	DSC 11 @ 4 credits DSC 12 @ 4 credits DSC 13 @ 4 credits DSC 14 @ 4 credits DSC 15 @ 4 credits	SEC 3/Internship 3 @ 4 credits	---	24
	IV	--	SEC4/Internship 4 @ 4 credits	Research thesis/project @20 credits	24

Only Research (only for the students who have completed 3 Years Bachelor's Program)					
	Semester	**Discipline-Specific Courses (DSC)**	**Skill Enhancement Courses (SEC) / Vocational Courses (VOC)/ Internship**	**Research thesis/project**	**Total Credits**
Option 3	**III**	**--**	**SEC3/Internship 3 @ 4 credits**	**20 credits***	**24**
	IV	**--**	**SEC4/Internship 4 @ 4 credits**	**20 credits****	**24**

Note:

***The students who opted Option 3 should submit a project report/synopsis of atleast 50 pages comprising of Literature survey, identification of Research Problem, Plan of work, methodology as well as practical work (if any) at the end of 3rd semester and the same will be evaluated by internal and external examiners.

**The students should continue the research work in 4th semester based on the project work/synopsis submitted at the end of 3rd semester. The final thesis/project report will be evaluated by the internal and external examiners.

Structure for 1 year Post Graduate Programme (2nd year of 2 Year PG Program)

	Semester	Discipline-Specific Courses (DSC)	Skill Enhancement Courses (SEC) / Vocational Courses (VOC)/Internship	Dissertation/ Project work	Total Credits
(STUDENT SHOULD SELECT ANY ONE OPTION)					
Only Course Work					
Option 1	**I (Semester III of 2 year PG Program)**	**DSC 11 @ 4 credits** **DSC 12 @ 4 credits** **DSC 13 @ 4 credits** **DSC 14 @ 4 credits** **DSC 15 @ 4 credits**	**SEC 3/Internship 3/ Project Work 1 @ 4 credits**	**---**	**24**
	II (Semester III of 2 year PG Program)	**DSC 16 @ 4 credits** **DSC 17 @ 4 credits** **DSC18 @ 4 credits** **DSC19 @ 4 credits** **DSC20 @ 4 credits**	**SEC4/Internship 4/ Project Work 2 @ 4 credits**	**---**	**24**
Course work and Research					
Option 2	**I (Semester III of 2 year PG Program)**	**DSC 11 @ 4 credits** **DSC 12 @ 4 credits** **DSC 13 @ 4 credits** **DSC 14 @ 4 credits** **DSC 15 @ 4 credits**	**SEC 3/Internship 3 @ 4 credits**	**---**	**24**
	II (Semester III of 2 year PG Program)	**--**	**SEC4/Internship 4 @ 4 credits**	**Dissertation/ Project work @ 20 credits**	**24**

Type of Course			Credits Distribution			Total Credits	Workload			Total Workload	Marks				
	Nomenclature `of Course	Course Code	L	T	P		L	T	P		Theory		Practical		Total Marks
											Internal	External	Internal	External	
Semester I (Session 2024-25)															
DSC 1 @ 4 credits	Real and Complex Analysis	24STA201DS01	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC 2 @ 4 credits	Probability Theory	24STA201DS02	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC 3 @ 4 credits	Statistical Methods	24STA201DS03	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC 4 @ 4 credits	Applied Statistics-I	24STA201DS04	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC 5 @ 4 credits	Data Analysis Using R	24STA201DS05	0	0	4	4	0	0	8	8	-	-	30	70	100
SEC1/VOC 1/ Internship 1 @ 4 credits	Data Visualization using Tableau & Power BI	24STA201SE01	0	0	4	4	0	0	8	8	-	-	30	70	100
Semester II (Session 2024-25)															
DSC 6 @ 4 credits	Measure Theory & Linear Algebra	24STA202DS01	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC 7 @ 4 credits	Inference-I	24STA202DS02	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC 8 @ 4 credits	Sampling Techniques	24STA202DS03	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC 9 @ 4 credits	Applied Statistics-II	24STA202DS04	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC 10 @ 4 credits	Operations Research	24STA202DS05	4	0	0	4	4	0	0	4	30	70	-	-	100
SEC2/VOC2/ Internship 2 @ 4 credits	Data Analysis Using SPSS	24STA202SE01	0	0	4	4	0	0	8	8	-	-	30	70	100

Type of Course			Credits Distribution			Total Credits	Workload			Total Workload	Marks				
	Nomenclature of Course	Course Code	L	T	P		L	T	P		Theory		Practical		Total Marks
											Internal	External	Internal	External	
OPTION – I (ONLY COURSE WORK)															
Semester III (Session 2025-26)															
DSC 11 @ 4 credits	Stochastic Processes	25STA203DS01	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC 12 @ 4 credits	Inference- II	25STA203DS02	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC 13 @ 4 credits	Design of Experiments	25STA203DS03	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC 14 @ 4 credits	Multivariate Analysis	25STA203DS04	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC 15 @ 4 credits	Information Theory	25STA203DS05	4	0	0	4	4	0	0	4	30	70	-	-	100
SEC 3/Internship 3/ Project Work 1 @ 4 credits	Research Methodology	25STA203SE01	4	0	0	4	4	0	0	4	30	70	-	-	100
Semester IV (Session 2025-26)															
DSC 16 @ 4 credits	Reliability Theory	25STA204DS01	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC 17 @ 4 credits	Econometrics	25STA204DS02	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC18 @ 4 credits	Optimization Techniques	25STA204DS03	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC19 @ 4 credits	Queuing Theory	25STA204DS04	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC20 @ 4 credits	Actuarial Statistics	25STA204DS05	4	0	0	4	4	0	0	4	30	70	-	-	100
SEC4/Internship 4/ Project Work 2 @ 4 credits	Regression Analysis Using SPSS	25STA204SE01	0	0	4	4	0	0	8	8	-	-	30	70	100
OPTION – II (COURSE WORK AND RESEARCH)															
Semester III (Session 2025-26)															
DSC 11 @ 4 credits	Stochastic Processes	25STA203DS01	4	0	0	4	4	0	0	4	30	70	-	-	100

DSC 12 @ 4 credits	Inference- II	25STA203DS02	4	0	0	4	4	0	0	4	30	70	-	-	100
DSC 13 @ 4 credits	Design of Experiments	25STA203DS03	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC 14 @ 4 credits	Multivariate Analysis	25STA203DS04	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC 15 @ 4 credits	Information Theory	25STA203DS05	4	0	0	4	4	0	0	4	30	70	-	-	100
SEC 3/Internship 3/ Project Work 1 @ 4 credits	Research Methodology	25STA203SE01	4	0	0	4	4	0	0	4	30	70	-	-	100
Semester IV (Session 2025-26)															
SEC4/ Internship 4 @ 4 credits	Regression Analysis Using SPSS	25STA204SE01	0	0	4	4	0	0	8	8	-	-	30	70	100
Research thesis/ project @20 credits	Dissertation/ Research Project	25STA204PD01	-	-	-	20	-	-	-	20	-	-	150	350	500
OPTION 3 (ONLY RESEARCH-ONLY FOR THE STUDENTS WHO HAVE COMPLETED 3 YEARS BACHELOR'S PROGRAM)															
Semester III (Session 2025-26)															
SEC 3/Internship 3/ Project Work 1 @ 4 credits	Research Methodology	25STA203SE01	4	0	0	4	4	0	0	4	30	70	-	-	100
Research thesis/ project @20 credits	Dissertation/ Research Project	25STA204PD01	-	-	-	20	-	-	-	20	-	-	150	350	500
Semester IV (Session 2025-26)															
SEC4/ Internship 4 @ 4 credits	Regression Analysis Using SPSS	25STA204SE01	0	0	4	4	0	0	8	8	-	-	30	70	100
Research thesis/ project @20 credits	Dissertation/ Research Project	25STA204PD01	-	-	-	20	-	-	-	20	-	-	150	350	500

L: Lecture; T: Tutorial; P: Practical

Syllabi for Post Graduate Program in Statistics

Semester I

Session: 2024-25

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Real and Complex Analysis	**Course Code**	24STA201DS01
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Acquired the Knowledge About Convergence Properties of Complex and Real Functions.
CLO 2: Students Acquired the Ability to learn differentiation techniques for complex functions
CLO 3: Students Acquired the Ability to understand applications of complex analysis in Bayesian inference
CLO 4: Students Acquired the Ability to understand the analytic properties of the complex functions
CLO 5: Students Acquired the Ability to Determine Integral of Complex Variables Functions

Unit 1: Topology of Real Numbers: Open Set, Closed Set, Limit Point of a Set, Bounds of a Set. Convergence and Divergence of Sequences. Cauchy's Theorem on Limits, Sequence and Series of Functions and their Convergence Properties.

Unit 2: Functions of a Complex Variable and their Analytic Properties. Cauchy's Riemann Equations. Power Series and Its Radius of Convergence. Elementary Idea of Mobius Transformation, Cross Ratio, Invariant Point and Critical Point.

Unit 3: Regular and Rectifiable Arcs, Contour, Domains: Connected, Simply Connected and Multiply Connected. Complex Line Integrals. Cauchy's Theorem, Cauchy's Integral Formulae and Inequality. Morera's Theorem. Liouvelle's Theorem. Taylor and Laurent Series.

Unit 4: Singularities and their Classification, Poles and Zeros of a Meromorphic Function, Argument Principle, Rouche's Theorem, Fundamental Theorem of Algebra, Residues, Cauchy's Residue Theorem, Application of Cauchy's Residue Theorem for Evaluation of Integrals of Real Valued Functions.

References:

1. Narayan, S. and Mittal, P.K. (2005). A Course of Mathematical Analysis. S. Chand.
2. Malik, S.C., & Arora, S. (2017). Mathematical Analysis. New Age International Publishers Pvt. Ltd.
3. Goyal, J.K., & Gupta, P.K. (2013). Functions of Complex Variable. Pragati Prakashan, Meerut.
4. Malik, S.C. (2018). Real and Complex Analysis. Jeevan Sons Publication, New Delhi.
5. Sharma, J.N. (2014). Functions of Complex Variable. Krishna Prakashan Media (P) Ltd.
6. Ahlfors, L. (2017). Complex Analysis. Mc Graw Hill.
7. Kasan, H.S. (2005). Complex Variables: Theory and Applications. PHI

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Probability Theory	**Course Code**	24STA201DS02
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Acquired A Base to Understand Fundamentals of Probability.
CLO 2: Students Acquired Knowledge about Random Variables, Probability Mass Function and Density Function
CLO 3: Students Acquired Knowledge to Understand Applications of Probability Theory in Real Life Problems
CLO 4: Students Acquired Knowledge to Formulate Generating Functions and Related Inequalities
CLO 5: Students Acquired The Ability to Understand the Applications of Law of Large Numbers and Central Limit Theorems

Unit 1: Random Experiment, Sample Space, Events – Simple, Composite, Mutually Exclusive and Exhaustive Events, Various Definitions of Probability, Properties of Probability Function, Addition Theorem, Boole's and Bonferroni's Inequalities, Conditional Probability, Multiplication Theorem, Bayes' Theorem, Independence of Events.

Unit 2: Random Variables and Distribution Functions, Probability Mass Function, Probability Density Function, Two Dimensional Random Variables- Joint, Marginal and Conditional Distributions, Independence of Random Variables. Moments of Random Variables: Expectation, Variance, Covariance, Conditional and Marginal Expectation.

Unit 3: Probability and Moment Generating Function and Their Properties, Characteristic Function and Its properties, Continuity Theorem Inversion Theorem, Uniqueness Theorem of Characteristic Function, Moment Inequalities of Hölder, Minkowski, Jensen's, Cauchy- Schwartz and Lyapunov's .

Unit 4: Modes of Convergence: Convergence in Probability, Almost Surely, in the rth Mean and in Distribution, Their Relationship. Probability Inequalities of Chebychev and Markov, Weak Law of large numbers: Chebychev's, Bernoulli's and Khintchine's Weak Law of Large Numbers, Necessary and Sufficient Conditions for the WLLN, Borel Cantelli Lemma, Kolmogorov Inequality, Strong Law of Large Numbers: Kolmogorov's Theorem. Central Limit Theorem: Lindeberg - Levy and Demoivre- Laplace Forms of CLT.

References:

1. Ross, S.M. (2016): A First Course in Probability, Pearson Education, India.
2. Biswas, D. (2016): Probability and Statistics, Vol. I, New Central Book Agency, New Delhi.
3. Palaniammal, S. (2011): Probability and Random Processes, Prentice Hall India Learning Private Limited, Delhi.
4. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
5. Kapoor, J.N. and Saxena, H.C. (2020): Mathematical Statistics, Sultan Chand & Sons, New Delhi.
6. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Private Limited, Kolkata.
7. Dharmaraja, S.: Introduction to Probability and Statistics, NPTEL Swayam Portal (URL: https://onlinecourses.nptel.ac.in/noc22_ma81/preview)

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Statistical Methods	**Course Code**	24STA201DS03
Hours per Week	3 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units

Course Learning Outcomes (CLO):

Students:

CLO 1: Students Understand the Concepts of Moments and Association of Attributes.

CLO 2: Students Achieved the Skills to Determine Correlation Between Variables.

CLO 3: Students Achieved the Knowledge to Apply Probability Distributions in Real Life Problems.

CLO 4: Students Attained the Knowledge About Various Sampling Distributions

CLO 5: Students Gained the Skills to Perform Hypothesis Testing For Small and Large Samples

Unit 1: Moments, Skewness and Kurtosis. Analysis and Consistency of Categorical Data, Independence and Association of Attributes. Principle of Least Squares, Fitting of Curves, Correlation and Regression.

Unit 2: Correlation Ratio. Interclass Correlation, Partial and Multiple Correlations. Discrete Probability Distributions: Binomial, Poisson, Multinomial, Hypergeometric, Geometric. Negative Binomial, Uniform.

Unit 3: Continuous Probability Distributions: Rectangular, Exponential, Normal, Beta, Gamma, Weibull, Laplace, Cauchy, Lognormal, Bivariate Normal. Sampling Distribution of Mean and Variance.

Unit 4: Large Sample Theory, Chi-Square, Student's and Snedecor's F, Fisher's-Z Distributions and Their Applications, Elementary Ideas of Non-Central Distributions.

References:

1. Hogg, R.V., Mckean, J.W., & Craig A.T. (2012). Introduction to Mathematical Statistics. Pearson.
2. Goon, A.M., Gupta, M.K., & Gupta B.D. (2013). Outline of Statistical Theory Vol. I. World Press.
3. Mukhopadhayaya, P. (2016). Mathematical Statistics. Books and Allied.
4. Mood, A.M., Graybill, F.A., & Boes, D.C. (2001).Introduction to the Theory of Statistics. Mc Graw Hill.
5. Gupta, S.C., & Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics. Sultan Chand & Sons, New Delhi

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Applied Statistics-I	**Course Code**	24STA201DS04
Hours per Week	3 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Familiarized with the Sources of Vital Statistics Data
CLO 2: Students Understand the Population Estimation and Projection
CLO 3: Students Acquainted with the Skills to Construct Complete and Abridged Life Tables
CLO 4: Students Familiarized with the Present Statistical Systems of INDIA
CLO 5: Students Got Information About the Working and Publications of NSSO and CSO

Unit 1: Methods of Obtaining Demographic Data, Measurement of Population at Given Time, Rates and Ratios, Measurement of Mortality: Crude Death Rate, Specific Death Rate, Standardized Death Rate, Infant Mortality Rate. Construction of a Complete Life Table and Its Uses. Abridged Life Tables: Kings Method, Reed & Merrill's Method, Greville's Method and Chiang's Method.

Unit 2: Measurement of Fertility: Crude Birth Rate, General Fertility Rate, Age Specific Fertility Rate, Total Fertility Rate, Relation Between TFR and CBR, Gross Reproduction Rate and Net Reproduction Rate, Replacement Index, Standardized Fertility Rate. Structure of Population, Stable and Quasi Stable Populations, Intrinsic Rate of Growth, Population Projection by Component Method, Reduction of Mortality Curves: Gompertz's and Makeham Formula, Logistic Curve and Its Use in Population Projection.

Unit 3: Demand Analysis: Laws of Demand and Supply. Elasticity of Demand: Price & Supply, Partial & Cross and Income. Utility Function Methods of Determining Demand and Supply Curves from Family Budget and Time Series Date, Leontief's Method, Pigou's Method Engel Curve and Its Different Forms, Pareto's Law of Income Distribution. Curves of Concentration.

Unit 4: Index Numbers and Their Construction, Uses of Index Numbers. Price, Quantity and Value Relatives, Link and Chain Relatives, Laspeyre's, Paashce's, Marshall–Edgeworth and Fisher's Index Numbers, Chain Base Index Numbers, Tests for Index Numbers. Base Shifting, Splicing and Deflating of Index Numbers, Cost of Living Index Numbers.

Official Statistics: Statistics System in India CSO and NSSO and Its Function, Present Structure of the Indian Statistical System, Function of a Statistical System, Agricultural Statistics, Trade Statistics, Labour and Employment Statistics, Transport and Communication Statistics, Financial and Banking Statistics.

References:

1. Goon, A.M., Gupta, M.K., & Gupta B.D. (2016): Fundamentals of Statistics, Vol-II. World Press.
2. Gupta, S.C., & Kapoor, V.K. (2014): Fundamental of Applied Statistics, Sultan Chand and Sons, New Delhi.
3. Mukhopadhyay, P. (2018): Applied Statistics, Books and Allied (P) Ltd.
4. Croxton, F.E., & Cowden, D.J. (1942): Applied General Statistics, Prentice-Hall, Inc.
5. Saluja, M.R. (2017): Measuring India: The Nation's Statistical System, OUP India.
6. Biswas, S., & Sriwastav G.L. (2014): Stochastic Processes in Demography and Applications, New Central Book Agency.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Data Analysis Using R	**Course Code**	24STA201DS05
Hours per Week	8 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: Note: There will be seven questions in all, and the students must attempt any five questions. The question paper will be set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:
Marks for Question Paper: 45
Marks for Practical Record Book: 15
Marks for Viva-Voce: 10
Total: 70

Course Learning Outcomes (CLO):
CLO 1: Students Acquired the Understanding of R Programming Language Syntax, Data Structures, and Functions.
CLO 2: Students Acquired the Knowledge of R Software for the Analysis of Complex Statistical Data coming from the Various Fields like Industry, Marketing, Finance, Agriculture and Business.
CLO 3: Students Acquired the Ability to Create Effective Data Visualizations using R Packages such as ggplot.
CLO 4: Students Acquired the Knowledge of Handling Missing Values, Outliers and Ensure Data Quality for Effective Analysis.
CLO 5: Students Acquired the Knowledge to Understand the Applications of R Programming in Statistics.

List of Practicals:
1. Create and Manipulate Various Data Objects, including Vectors, Matrices, and Data Frames.
2. Practice Manipulating Data using Functions like Subset, Merge, and Other Operations on Data Frames.
3. Perform Operations on Matrices, including Addition, Multiplication, Subtraction, Transpose, and Inversion.
4. Merge two or More Data Frames using Different Methods and Explore the Resulting Data.
5. Identify and Handle Missing Values and Duplicated Observations in a Dataset.
6. Create Various Plots, including Histogram, Boxplot, Stem and Leaf Plot, and Scatter Plot.
7. Use ggplot to Create Advanced and Customizable Plots.
8. Calculate and Interpret Measures of Central Tendency (Mean, Median, Mode) and Dispersion (Variance, Standard Deviation) using R Codes.
9. Compute Covariance and Correlation Coefficients between Variables in a Dataset using R.
10. Explore Various Distribution Functions and Apply Methods of Estimation in R.
11. Check the Independence and Association of Attributes.
12. Check the Consistency of Categorical Data.
13. Perform Small Sample Tests
14. Perform Large Sample Tests
15. Find the Best Fitted Line using the Method of Curve Fitting.
16. Fit the Simple Linear Regression and Assess the Significance of Obtained Model.
17. Compare the Median of a Single Sample to a Known Value or Test the Difference between Paired Observations using Wilcoxon Signed Rank Test.
18. Compare the Distributions of Two Independent Samples using Mann Whitney Test.
19. Compare the Distributions of Three or More Independent Samples using Kruskal Wallis Test.
20. Test the Association between Two Categorical Variables using Chi Square Test.
21. Compare Three or More Matched Groups (Repeated Measures) When the Dependent Variable is Ordinal using Friedman Test.

References:
1. Rakshit, S (2018): Statistics with R Programming. McGraw Hill Education.
2. Grolemund, G. (2014): Hands on Programming with R. O′Reilly.
3. Vries, A. de and Meys, J. (2012): R for Dummies. John Wiley & Sons.
4. Lander, J.P. (2017): R for Everyone. Addison-Wesley Professional.
5. Srinivasa, K.G., Siddesh, G.M., Shetty, C. and Sowmya, B.J. (2017): Statistical Programming in R. Oxford University Press.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Data Visualization Using Tableau & Power BI	**Course Code**	24STA201SE01
Hours per Week	3 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: Note: There will be seven questions in all, and the students must attempt any five questions. The question paper will be set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

Marks for Question Paper: 45
Marks for Practical Record Book: 15
Marks for Viva-Voce: 10
Total: 70

Course Learning Outcomes (CLO):

CLO 1: Students Able to Learn Basic Working of Tableau and Power BI
CLO 2: Students Achieved the Knowledge About Different Types of Data and Scales of Their Measurement
CLO 3: Students Gained the Ability to Perform a Wide Range of Data Management Tasks
CLO 4: Students Acquainted the Technique to Handle Data Visualization
CLO 5: Students Able To Perform Interactive Dashboards

List of Practicals:

1. Import Various Datasets into Tableau and Power BI, Clean and Prepare the Data for Visualization.
2. Create Bar Charts, Line Graphs, Scatter Plots, and Pie Charts using Different Data Sets and Customize Colors, Labels, and Formatting.
3. Compare Different Categories within a Dataset using Visualizations like Stacked Bar Charts, Side-by-Side Bar Charts, or Box Plots to Understand Relationships and Variances.
4. Analyse a Dataset to Identify Trends Over Time. Use Line Graphs or Area Charts to Visualize How Specific Metrics Change Over a Period.
5. Create Calculated Fields and Understand Their Applications in Visualizations.
6. Use IF Statements and Mathematical Functions.
7. Use Parameters to Create Dynamic, Interactive Visualizations.
8. Build an Interactive Dashboard from Scratch using Multiple Visualizations. Allow Users to Filter, Highlight, and Interact with the Data to Draw their Insights.
9. Use Geographic Data to Create Maps that Showcase Regional Variations or Patterns. Explore Demographics, Sales Data, or Any Other Geospatial Dataset to Create Meaningful Visualizations.
10. Combine Data from Multiple Sources to Create a Blended Worksheet.
11. Create a Narrative using Data and Tableau Visualizations to Convey a Compelling Story and Use Annotations, Text, and Images to Enhance Storytelling.

References:

1. Guillevin, G. (2019): Getting Started with Tableau, Packt Publishing Limited, India.
2. Santos, D. (2016): Tableau 10 Business Intelligence Cookbook, Packt Publishing Limited, India.
3. Milligan, J.N. (2022): Learning Tableau, Ingram Short Title, India.
4. Sleeper, R. (2018): Practical Tableau, Shroff/O'Reilly, India.
5. Ryan, L. (2018): Visual Data Storytelling with Tableau, Pearson Education, United Kingdom.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Measure Theory & Linear Algebra	**Course Code**	24STA202DS01
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students will Able To Understand the Concepts of Field and Sigma Field in Measure Theory.
CLO 2: Students will Able To Understand the Applications of Measure Theory in Probability Theory.
CLO 3: Students will Able To Understand the Concepts of Simple Functions and Sequences in the Algebra of Measurable Functions.
CLO 4: Students will Able To Explore Convergence in Measure and Its Fundamental Principles.
CLO 5: Students will Able To Understand the Concept of Lebesgue Integral

Unit 1: Field and Sigma Field. Measure and Probability Measure. Outer Measurability of Sets. Class of Measurable Sets. Construction of Outer Measure using Sequential Concerning Classes. Lebesgue Measure. Construction of Non-Measurable Sets.

Unit 2: Measurable Function as a Random Variable. Simple Functions. Sequences and Algebra of Measurable Functions. Approximation Theorem of Measurable Functions. Concepts of Almost Everywhere (a.e) and Almost Uniform Convergence. Egoroffs Theorem. Lusin Theorem.

Unit 3: Convergence in Measure. Fundamental in Measure. F.Riesz Theorem for Convergence in Measure. Integral of a Measurable Function w.r.t. a Measure. Bounded Convergence Theorem. Fatou's Lemma, Monotone Convergence Theorem. General Lebesgue Integral and Lebesgue Dominated Convergence Theorem.

Unit 4: Linear and Orthogonal Transformation of a Matrix. Eigen Values and Eigen Vectors of a Liner Transformation. Quadratic Forms and Their Reduction to Canonical Form. Signature of a Matrix. Positive Definite Matrix.

References:

1. Rana, I.K. (2007): An Introduction to Measure and Integration, Narosa Publication.
2. Jain, P.K, Gupta, V.P., & Jain, P. (2019): Lebesgue Measure and Integration, New Age International Publishers.
3. Halmos, P.R. (2008): Measure Theory, Springer.
4. De Barra, G. (2013): Measure Theory and Integration, New Age International Publisher.
5. Datta, K.B. (2004): Matrix and Linear Algebra, Prentice-Hall of India Pvt. Ltd.
6. Lay, D.C. (2002): Linear Algebra and Its Applications, Pearson.
7. Hoffman, K., & Kunze, R. (2015): Linear Algebra, Pearson.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Inference-I	**Course Code**	24STA202DS02
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Acquired Ability to Estimate Unknown Parameters of a Given Probability Distribution.

CLO 2: Students Achieved the Ability to Understand the Properties of a Good Estimator for Parameters of Different Probability Distributions.

CLO 3: Students Obtained knowledge to determine the Optimal Estimator for a Given Parametric Function.

CLO 4: Students Learned the Ability to compute Critical Region (CR) and Best Critical Region (BCR).

CLO 5: Students Gained the skills to Apply MP Test, UMP Test and LRT Test.

Unit 1: Point Estimation, Estimator & Its Properties, Neyman Factorization Theorem, Complete Sufficient Statistic, Exponential Family of Distributions and its Properties, Minimum Variance Unbiased (MVU) Estimators, Mean-Squared Error, Fisher's Information Measure, Cramer-Rao Inequality, Minimum Variance Bound (MVB) Estimators, Bhattacharya's Bounds

Unit 2: Rao-Blackwell Theorem, Lehman Schefe's Theorem and its Applications in Finding Uniformly Minimum Variance Unbiased Estimators. Methods of Estimation: Maximum Likelihood, Moments, Least Square, Minimum Chi-Square and Modified Minimum Chi-Square and Their Properties.

Unit 3: Neyman Theory of Testing of Hypothesis, Simple and Composite Hypotheses, Null and Alternative Hypotheses, Type of Errors, Critical Region, Level of Significance, Power of the Test, Unbiased Tests, Critical Region, N-P Lemma, Construction of Most Powerful Test, Uniformly Most Powerful Test, Uniformly Most Powerful Unbiasedness Tests.

Unit 4: Likelihood Ratio Test: Derivation and Its Properties, Asymptotic Distribution of L.R. Test. IntervalEstimation: Method of Obtaining Confidence Intervals Based on Small and Large Samples. Unbiasedand Shortest Expected Length Confidence Interval.

References:

1. Goon, A.M., Gupta, M.K., & Gupta B.D. (2013). Outline of Statistical Theory Vol. II. World Press.
2. Rohatgi, V. K., & Saleh, A.K. Md. E. (2008). An Introduction to Probability and Statistics. Wiley.
3. Rao, C .R. (2002). Linear Statistical Inference and its applications. Wiley.
4. Gupta, S.C., & Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics. Sultan Chand & Sons, New Delhi.
5. Kendall, M.G., & Stuart, A. (1979). Advanced Theory of Statistics. Charles Griffin & Co. Ltd.
6. Hogg, R.V., Tanis, E.A., & Zimmerman, D.L. (2019).Probability and Statistical Inference. Pearson.
7. Casella, G., & Berger, R.L. (2006). Statistical Inference. Cengage

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Inference-I (Practical)	**Course Code**	24STA202DS02
Hours per Week	2 Hours	**Credits**	1
Maximum Marks	25 {External (term-end exam) – 20} (Internal – 5)	**Time of Examinations**	1½ Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:
Marks for Question Paper: 12
Marks for Practical Record Book: 05
Marks for Viva-Voce: 03
Total: 20

Course Learning Outcomes (CLO):

CLO 1: Students Acquired Ability to Estimate Unknown Parameters of a Given Probability Distribution.
CLO 2: Students Achieved the Ability to Understand the Properties of a Good Estimator for Parameters of Different Probability Distributions.
CLO 3: Students Obtained knowledge to determine the Optimal Estimator for a Given Parametric Function.
CLO 4: Students Learned the Ability to compute Critical Region (CR) and Best Critical Region (BCR).
CLO 5: Students Gained the skills to Apply MP Test, UMP Test and LRT Test.

List of Practical's:

1. Unbiased Estimators (Including Unbiased but Absurd Estimators).
2. Consistent Estimators, Efficient Estimators and Relative Efficiency of Estimators.
3. Cramer-Rao Inequality and MVB Estimators.
4. Sufficient Estimators: Factorization Theorem, Rao-Blackwell Theorem,
5. Complete Sufficient Estimators.
6. Lehman-Scheffe Theorem and UMVUE.
7. Maximum Likelihood Estimation.
8. Asymptotic Distribution of Maximum Likelihood Estimators.
9. Estimation by the Method of Moments, Minimum Chi-Square.
10. Type I and Type II Errors.
11. Most Powerful Critical Region (NP Lemma).
12. Uniformly Most Powerful Critical Region.
13. Unbiased Critical Region.
14. Power Curves.
15. Likelihood Ratio Tests for Simple Null Hypothesis against Simple Alternative Hypothesis.
16. Likelihood Ratio Tests for Simple Null Hypothesis against Composite Alternative Hypothesis.
17. Asymptotic Properties of LR Tests.
18. To Construct Confidence Intervals Based on Small and Large Samples.

References:

1. Goon, A.M., Gupta, M.K., & Gupta B.D. (2013). Outline of Statistical Theory Vol. II. World Press.
2. Rohatgi, V. K., & Saleh, A.K. Md. E. (2008). An Introduction to Probability and Statistics. Wiley.
3. Rao, C .R. (2002). Linear Statistical Inference and its applications. Wiley.
4. Gupta, S.C., & Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics. Sultan Chand & Sons, New Delhi.
5. Kendall, M.G., & Stuart, A. (1979). Advanced Theory of Statistics. Charles Griffin & Co. Ltd.
6. Hogg, R.V., Tanis, E.A., & Zimmerman, D.L. (2019).Probability and Statistical Inference. Pearson
7. Casella, G., & Berger, R.L. (2006). Statistical Inference. Cengage

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Sampling Techniques	**Course Code**	24STA202DS03
Hours per Week	3 Hours	**Credits**	3
Maximum Marks	75 {External (term-end exam) – 50}(Internal – 25)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students attained The Skill to Plan the Large-Scale Nation-Wide Sample Surveys

CLO 2: Students attained The Knowledge to Identify and Define the Population to be Studied & Control of Non-Sampling Errors

CLO 3: Students attained The Ability to Understand the Schemes of SRS and Stratified Sampling

CLO 4: Students attained The Ability to Use Auxiliary Information at the Estimation Stage

CLO 5: Students attained The Knowledge of the Schemes of Cluster Sampling, Multi-Stage, Multi-Phase Sampling and PPS Sampling

Unit 1: Sample Versus Complete Enumeration, Designing of Sample Surveys, Sources of Errors in Sample Surveys, Types of Non-Response Errors Probability and Purposive Sampling, Simple Random Sampling with or without Replacement for The Estimation of Mean Total. Proportion and Ratio, Determination of Sample Size for Specified Precision Stratified Sampling: Proportional and Optimum Allocation. Estimation of Gain Due To Stratification. Construction of Strata and Determination of Number of Strata

Unit 2: Ratio Estimates, Approximate Variance, Comparison with Mean Per Unit Estimate. Optimum Conditions, Bias of The Ratio Type Estimate, Unbiased Ratio Type Estimate Due to Hartley and Ross, Ratio Estimate in Stratified Sampling. Regression Estimators (Pre –Assigned and Estimated from the Sampling Comparison with the Ratio and Mean per Unit Estimates in Stratified Sampling.

Unit 3: Double Sampling (Two Phase Sampling) for Ratio and Regression Methods of Estimation. Systematic Sampling, Comparison with Stratified and Simple Random Sampling, Single Stage Cluster Sampling and Variance in terms of Inter Cluster Correlation. Jessen's cost Function and Determination of Optimum Sampling Unit.

Unit 4: Sampling with Varying Probability, Sampling with Probability Proportional to Size Lahiri Method of Selection Unequal Probability Sampling with Replacement and without Replacement Horvitz Thompson Estimator, its Variance and Unbiased Estimate of this Variance. Two Stage Sampling, Estimate of Population Mean and its Variance, Optimum Allocation for Fixed Cost.

References:

1. Goon, A.M., Gupta, M.K., & Gupta, B.D. (2016). Fundamentals of Statistics, Vol-II. World Press.
2. Singh, D., & Chaudhary, F.S. (2018). Theory & Analysis of Sample Survey Designs. New Age International Private Limited.
3. Gupta, S.C., & Kapoor, V.K. (2014). Fundamentals of Applied Statistics, Sultan Chand & Sons.
4. Raj, D., & Chandhok, P. (2013). Sample Survey Theory. Createspace Independent Publication.
5. Hansen, M.H., Hurwitz, W.N., & Madow, W.G. (1993). Sample Survey Methods and Theory. Wiley.
6. Shalabh: Sampling Theory, NPTEL Swayam Portal
   (URL: https://archive.nptel.ac.in/courses/111/104/111104073/)

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Sampling Techniques (Practical)	**Course Code**	24STA202DS03
Hours per Week	2 Hours	**Credits**	1
Maximum Marks	25 {External (term-end exam) – 20} (Internal – 5)	**Time of Examinations**	1½ Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:
Marks for Question Paper: 12
Marks for Practical Record Book: 05
Marks for Viva-Voce: 03
Total: 20

Course Learning Outcomes (CLO):
CLO 1: Students attained The Skill to Plan the Large-Scale Nation-Wide Sample Surveys
CLO 2: Students attained The Knowledge to Identify and Define the Population to be Studied & Control of Non-Sampling Errors
CLO 3: Students attained The Ability to Understand the Schemes of SRS and Stratified Sampling
CLO 4: Students attained The Ability to Use Auxiliary Information at the Estimation Stage
CLO 5: Students attained The Knowledge of the Schemes of Cluster Sampling, Multi-Stage, Multi-Phase Sampling and PPS Sampling

List of Practical's:
1. To Select a Simple Random Sample (SRS) With and Without Replacement.
2. For a Population of Size 'n' (fixed), Estimate Population Mean, Population Mean Square and Population Variance. Enumerate all Possible Sample of size 'a'(<n) by WR and WOR method and establish all properties relative to SRS.
3. Estimate Mean, Standard Error, the Sample Size for SRS Without Replacement.
4. Stratified Sampling: Allocation of Sample to Strata by Proportional Method.
5. Stratified Sampling: Allocation of Sample to Strata by Neyman's Method.
6. Estimation of Gain in Precision in Stratified Sampling.
7. Comparison of Systematic with Simple Random Sampling.
8. Comparison of Systematic with Stratified Sampling.
9. Estimate the Ratio of Two Population Characteristics
10. Estimation of Population Parameters for the given data using Ratio and Regression Estimators. Compare the Efficiencies of Ratio and Regression Estimators Relative to SRS.
11. Estimation of Mean or Total, Variance of the Estimate, Estimate of Intra-Class Correlation Coefficient for Cluster Sampling.

References:
1. Goon, A.M., Gupta, M.K., & Gupta, B.D. (2016). Fundamentals of Statistics, Vol-II. World Press.
2. Singh, D., & Chaudhary, F.S. (2018). Theory & Analysis of Sample Survey Designs. New Age International Private Limited.
3. Gupta, S.C., & Kapoor, V.K. (2014). Fundamentals of Applied Statistics, Sultan Chand & Sons.
4. Raj, D., & Chandhok, P. (2013). Sample Survey Theory. Createspace Independent Publication.
5. Hansen, M.H., Hurwitz, W.N., & Madow, W.G. (1993). Sample Survey Methods and Theory. Wiley.
6. Shalabh: Sampling Theory, NPTEL Swayam Portal (URL: https://archive.nptel.ac.in/courses/111/104/111104073/)

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Applied Statistics-II	**Course Code**	24STA202DS04
Hours per Week	3 Hours	**Credits**	3
Maximum Marks	75 {External (term-end exam) – 50}(Internal – 25)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Attained the Knowledge and Understanding of Time Series Analysis.
CLO 2: Students Acquired the Skills to Measure and Analyze the Cyclic Component of Time Series Data using Methods such as Harmonic and Periodogram Analysis.
CLO 3: Students Achieved the Ability to Implement Box-Jenkins Models and Estimate Parameters in ARIMA Models.
CLO 4: Students Understand the Importance of Quality Control in Maintaining Product/Service Standards.
CLO 5: Students Gained Hands-on Experience in Creating and Interpreting Control Charts.

Unit 1: Analysis of Time Series, Components of Time Series, Trend Measurement by Mathematical Curves: Polynomial, Growth Curves. Moving Average Method, Spencer's Formulae, Effect of Elimination of Trend on Other Components of Time Series. Variate Difference Method and its Use for Estimation of Variance of the Random Component. Measurement of Seasonal Fluctuations, Measurement of Cyclical Component, Periodogram Analysis.

Unit 2: Concept of Stationary Time Series, Strong and Weak Stationary: Auto Covariance and Auto Correlation, Augmented Dickey-Fuller Test, Correlogram of Auto Regressive Scheme. Moving Average Scheme and A Harmonic Series. Box Jenkin's Models, Estimation of Parameters in ARIMA Models, Forecasting: Exponential and Adaptive Smoothing Models.

Unit 3: Statistical Quality Control and Its Purposes, 3 Sigma Control Limit, Shewhart's Control Chart. Control Charts For Variables and Attributes, Natural Tolerance Limits and Specification Limits: Modified Control Limits. Sampling Inspection Plan, Producer's and Consumer's Risk OC and ASN Function, AQL, LTPD and ATI.

Unit 4: Single, Double and Sequential Sampling Plans and their Curves including AOQ, OC, ASN and ATI. Choice of Sampling Plans by Attributes and by Variables. Acceptance Plan by Variables, Single and Sequential Sampling Plans. Acceptance Sampling by Variables (Known and Unknown Sigma Case).

References:

1. Goon, A.M., Gupta, M.K., and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edition. The World Press, Kolkata.
2. Mukhopadhyay, P. (2011): Applied Statistics, 2nd Edition Revised Reprint, Books and Allied(P) Ltd.
3. Montgomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition Reprint, Wiley India Pvt. Ltd.
4. Gupta, S.C. and Kapoor, V.K. (2007): Fundamentals of Applied Statistics. 4th Edition, Sultan Chand and Sons, New Delhi.
5. Shumway, R.H. and Stoffer, D.S. (2011): Time Series Analysis and Its Application. 3rd Edition, Springer.
6. Croxton, F.E., & Cowden, D.J. (1942). Applied General Statistics. Prentice-Hall, Inc.
7. Grant, E.L. (1946). Statistical Quality Control. McGraw Hill.
8. Montgomery, D.C. (2008). Introduction to Statistical Quality Control. John Wiley and Sons

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Applied Statistics-II (Practical)	**Course Code**	24STA202DS04
Hours per Week	2 Hours	**Credits**	1
Maximum Marks	25 {External (term-end exam) – 20} (Internal – 5)	**Time of Examinations**	1½ Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:
Marks for Question Paper: 12
Marks for Practical Record Book: 05
Marks for Viva-Voce: 03
Total: 20

Course Learning Outcomes (CLO):
CLO 1: Students Attained the Knowledge and Understanding of Time Series Analysis.
CLO 2: Students Acquired the Skills to Measure and Analyze the Cyclic Component of Time Series Data using Methods such as Harmonic and Periodogram Analysis.
CLO 3: Students Achieved the Ability to Implement Box-Jenkins Models and Estimate Parameters in ARIMA Models.
CLO 4: Students Understand the Importance of Quality Control in Maintaining Product/Service Standards.
CLO 5: Students Gained Hands-on Experience in Creating and Interpreting Control Charts.

List of Practical's:
1. Analyze the Components of Time Series Data using Decomposition Techniques. Also, Identify and discuss the trend present in the time series data.
2. Apply the Method of Simple Averages to Measure Seasonal Fluctuations in a Given Time Series.
3. Use the Ratio to Trend Method and Ratio to Moving Average Method for Seasonal Adjustment.
4. Implement the Link Relative Method to Compare and Analyze Different Time Series Data.
5. Perform Augmented Dickey-Fuller Test to Check the Stationarity in a Given Time Series Dataset.
6. Conduct Harmonic Analysis on a Time Series with Cyclic Components.
7. Use the Periodogram Analysis Technique to Identify Cyclical patterns.
8. Apply the Variate Difference Method to Measure and Interpret the Cyclic Component in a Given Time Series.
9. Build an ARIMA Model using Box-Jenkins Methodology for a Time Series Dataset.
10. To Develop and Interpret the chart for a Manufacturing Process.
11. Construct and Interpret the chart for a Manufacturing Process
12. Construct and Interpret Control Chart for Fraction Defective.
13. Construct and Interpret the Control Chart for the Non-Conforming Unit for Per Unit.
14. To Develop the Operating Characteristic (OC) Curves and Average Total Inspection (ATI) Curves, Average Outgoing Quality Limit (AOQL) for Simple Sampling Plan.
15. To Develop the Operating Characteristic (OC) Curves and Average Total Inspection (ATI) Curves, Average Outgoing Quality Limit (AOQL) for Double Sampling Plan.
16. To Implement and Analyze a Sequential Sampling Plan for Quality Control and Interpret the OC, AOQL, ATI and AOQ.

References:
1. Goon, A.M., Gupta, M.K., and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edition. The World Press, Kolkata.
2. Mukhopadhyay, P. (2011): Applied Statistics, 2nd Edition Revised Reprint, Books and Allied(P) Ltd.
3. Montgomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition Reprint, Wiley India Pvt. Ltd.
4. Gupta, S.C. and Kapoor, V.K. (2007): Fundamentals of Applied Statistics. 4th Edition, Sultan Chand and Sons, New Delhi.
5. Shumway, R.H. and Stoffer, D.S. (2011): Time Series Analysis and Its Application. 3rd Edition, Springer.
6. Croxton, F.E., & Cowden, D.J. (1942). Applied General Statistics. Prentice-Hall, Inc.
7. Grant, E.L. (1946). Statistical Quality Control. McGraw Hill.
8. Montgomery, D.C. (2008). Introduction to Statistical Quality Control. John Wiley and Sons

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Operations Research	**Course Code**	24STA202DS05
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Attained the Skills to Form and Solve Deterministic and Probabilistic Inventory Models and Purchase Inventory Models with One, Two and Any Number of Price Break.

CLO 2: Students Achieved the Ability to Solve Job Sequencing Problem of N Jobs through 2, 3 and M Machines.

CLO 3: Students Acquired the Understanding to Use CPM and PERT Methods in Effective Project Management.

CLO 4: Students Acquainted with Methods for the Solution of Transportation and Assignment Problems.

CLO 5: Students Attained Knowledge to Understand Probabilistic Models with Applications of Stochastic Processes in Solving Real Life Problems.

Unit 1: Definition and Scope of Operations Research and Its Role In Decision-Making, its Characteristics, Phases, Different Types of Models, Their Construction and General Methods of Solution Replacement Problem, Replacement of Items That Deteriorate, Replacement of Items That Fails Completely Individual Replacement Policy: Motility Theorems, Group Replacement Policy, Recruitment and Promotion Problems.

Unit 2: Inventory Problems, Costs Involved In Inventory Problems, Classification of Inventory System. Deterministic and Probabilistic Inventory Models, Purchase Inventory Model, Purchase Inventory Model with One, Two and Any Number of Price Break.

Unit 3: Job Sequencing Problems; Introduction and Assumption, Processing of N Jobs Through Two Machines (Johnson's Algorithm) Processing of N Jobs Through Three Machines and M Machines, Processing Two Jobs Through N Machines (Graphical Method) Simulation Definition, Types, Uses and Limitation of Simulation Phases, Simulation Models, Monte Carlo Simulation, Application of Simulation.

Unit 4: PERT/CPM: Development Uses and Application of PERT/CPM Techniques, Network Diagram Representation Fulkerson 1-J Rule for Labelling Time Estimate and Determination of Critical Path on Network Analysis, PERT Techniques, Crashing.

References:

1. Sharma, S.D. (2012). Operation Research. Kedar Nath Ram Nath.
2. Taha, H.A. (2014). Operations Research: An Introduction. Pearson.
3. Sharma, J.K. (2017). Operations Research: Theory and Applications. Laxmi Publication.
4. Gupta, R.K. (2010). Operations Research. Krishna Prakashan Media.
5. Churchman, C.W. (1957). Introduction to Operations Research. John Wiley and Sons.
6. Iyer, P.S. (2008). Operations Research. Mc Graw Hill.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Data Analysis Using SPSS	**Course Code**	24STA202SE01
Hours per Week	8 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam)-70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: There will be seven questions in all, and the students must attempt any five questions. The question paper will be set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:
Marks for Question Paper: 45
Marks for Practical Record Book: 15
Marks for Viva-Voce: 10
Total: 70

Course Learning Outcomes (CLO):
Students Acquired the:

- Knowledge to Understand Presentation and Interpretation of the Data in SPSS
- Understanding of the Measures of Central Tendency and Dispersion, Correlation in SPSS
- Knowledge to Understand Fitting of Probability Distributions in SPSS
- Ability to apply Parametric and Non-Parametric Tests
- Skill to Perform Simple Linear Regression in SPSS

List of Practical's:

1. Presentation of the Data through Different Tables and Graphs
2. Compute the Measures of Central Tendency and Dispersion for a Dataset
3. Determine the Correlation Coefficient.
4. Determine the Spearman's Rank Correlation.
5. Check the Independence and Association of Attributes.
6. Check the Consistency of Categorical Data.
7. Perform the Test to Check the Normality of Dataset.
8. Perform Small Sample Tests
9. Perform Large Sample Tests
10. Find Confidence Interval to Estimate the Parameters.
11. Perform One-Way and Two-Way ANOVA
12. Find the Best Fitted Line using the Method of Curve Fitting.
13. Fit the Simple Linear Regression and Assess the Significance of Obtained Model.
14. Compare the Median of a Single Sample to a Known Value or Test the Difference between Paired Observations using Wilcoxon Signed Rank Test.
15. Compare the Distributions of Two Independent Samples using Mann Whitney Test.
16. Compare the Distributions of Three or More Independent Samples using Kruskal-Wallis Test.
17. Test the Association between Two Categorical Variables using Chi Square Test.
18. Compare Three or More Matched Groups (Repeated Measures) When the Dependent Variable is Ordinal using Friedman Test.

References

1. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Private Limited, Kolkata.
2. Kapoor, J.N. and Saxena, H.C. (2020): Mathematical Statistics, Sultan Chand & Sons, New Delhi.
3. Cunningham, B.J. (2012): Using SPSS: An Interactive Hands-on Approach, Sage South Asia.
4. Field, A. (2013): Discovering Statistics Using SPSS, Fourth Edition, SAGE.
5. Hogg, R.V., Tanis, E.A., & Zimmerman, D.L. (2019): Probability and Statistical Inference. Pearson.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Stochastic Processes	**Course Code**	25STA203DS01
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Understand the Use of Probability Generating Functions.
CLO 2: Students Acquired Knowledge About Different Types of Stochastic Processes.
CLO 3: Students Achieved the Ability to the Basic Concepts of Theory of Markov Chain.
CLO 4: Students Obtained Understanding for the Solution of Stochastic Differential Equations.
CLO 5: Students Gained Skills to Obtain Probability of Ultimate Extinction and Duration of the Game.

Unit 1: Probability Generating Function: Binomial, Poisson, Geometric and Negative Binomial Distributions. Bivariate Probability Generating Function. Stochastic Processes: Definition, Classification and Examples. Compound Distributions: Mean, Variance and Examples.

Unit 2: Markov-Chains: Classification of States and Chain, Chapman-Kolmogorov Equation, Higher Transition Probabilities, Stability of Markov Systems and Limiting Behaviour. Poisson Process: Classifications, Decomposition and Related Distributions and Generalization.

Unit 3: Birth and Death Processes: Yule-Furry Process and Generalization. Linear Birth-Death Process Branching Processes: Properties of Generating Functions, Probability of Extinction and Distribution of Total Progeny. Random Walk: First Passage Time, Gambler's Ruin Problem and Duration of the Game.

Unit 4: Renewal Processes: Renewal Process in Discrete & Continuous Time, Forward Renewal Equation, Renewal Function and Density, Renewal Theorems, Central Limit Theorem for Renewal Process, Delayed and Equilibrium Renewal Process, Residual and Excess Life Times Renewal Process, Poison Process as a Renewal Process.

References:

1. Medhi, J. (2019). Stochastic Processes. New Age International.
2. Baily, N.T.J. (1990). The Elements of Stochastic Processes with Applications to the Natural Sciences. Wiley-Interscience.
3. Bhatt, B.R. (2000). Stochastic Models, Analysis and Application. New Age International Pvt. Ltd.
4. Cox, D.R., & Miller, H.D. (2001). The Theory of Stochastic Processes. Chapman and Hall/CRC.
5. Harris, T.E. (1963). The Theory of Branching Processes. Springer.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Inference-II	**Course Code**	25STA203DS02
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Attained the Ability to Test Hypothesis using Sequential Procedure

CLO 2: Students Got the Knowledge to Determine ASN and OC Functions of SPRT

CLO 3: Students Acquired Understanding of Decision Function, Admissible Decision Rules, Risk function and Average Risk function, Bayes' risk and Minimax Risk

CLO 4: Students Gained the Knowledge About the PDF of Order Statistics & Functions of Order Statistics, and also the Asymptotic Distribution of Order Statistics

CLO 5: Students Attained the Skills to Perform Hypothesis Testing of One Sample and Two Samples for Location Problem.

Unit 1: Sequential Analysis: Sequential Testing Procedure, OC and ASN Functions, Wald's SPRT, Strength of SPRT and Determination of Its Stopping Bounds, Stopping Rule. Determinations of OC and ASN Functions of SPRT, Wald's Fundamental Identity and Its Use In The Derivation of ASN Function of SPRT.

Unit 2: Basic Elements of Decision Theory: Decision Function, Risk Function, Randomization, Optimal Decision Rules: Bayes' and Minimax Decision Rule, The Least Favorable Distribution, Convex Loss Function. The form of Bayes' Rules for Estimation Admissibility and Completeness. Existence of Minimal Complete Class.

Unit 3: Non-Parametric Theory: Concept of Non-Parametric and Distribution Free Methods, Order Statistics, Their Marginal and Joint Distributions. Distributions of Median, Range and Coverage; Moments of Order Statistics. Asymptotic Distribution of Order Statistics.

Unit 4: Non-Parametric Tests: One Sample and Paired Sample Problems. Ordinary Sign Test, Wilcoxon Signed Ranked Test, and Their Comparison. General Problem of Tied Differences. Goodness of Fit Problem: Chi-Square Test and Kolmogrov – Smirnov One Sample Test, and Their Comparison. Two Sample Problems: K-S Two Sample Test, Wald – Wolfwitz Run Test, Mann –Whiteney U Test, Median Test.

References:

1. Goon, A.M., Gupta, M.K., & Gupta B.D. (2013). Outline of Statistical Theory Vol. II. World Press.
2. Rohatgi, V. K., & Saleh, A.K. Md. E. (2008). An Introduction to Probability and Statistics. Wiley.
3. Rao, C .R. (2002). Linear Statistical Inference and its applications. Wiley.
4. Gupta, S.C., & Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics. Sultan Chand & Sons, New Delhi.
5. Kendall, M.G., & Stuart, A. (1979). Advanced Theory of Statistics. Charles Griffin & Co. Ltd.
6. Hogg, R.V., Tanis, E.A., & Zimmerman, D.L. (2019).Probability and Statistical Inference. Pearson.
7. Casella, G., & Berger, R.L. (2006). Statistical Inference. Cengage

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Design of Experiments	**Course Code**	25STA203DS03
Hours per Week	3 Hours	**Credits**	3
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Acquired the Proficiency in Assessing the Appropriateness of Experimental Designs in Handling Extraneous Variables.

CLO 2: Students Acquired the Competence in Designing and Analyzing Experiments for Both One-Directional and Two-Directional Variations.

CLO 3: Students Acquired the Proficiency in the Analysis of Specific Experimental Designs such as CRD, RBD and LSD.

CLO 4: Students Acquired the Skill in Estimating Missing Observations and Subsequently Conducting a thorough Analysis of the Experimental Data.

CLO 5: Students Acquired the Profound Understanding of Treatment Allocation in Factorial Experiments with Two Levels and Adeptness in Analyzing Such Designs using Yate's Technique.

Unit 1: Linear Models: Standard Gauss Markov Models, Estimation of Parameters, Best Linear Unbiased Estimator, Method of Least Squares, Gauss-Markov Theorem, Variance-Covariance Matrix of BLUEs.

Unit 2: General Theory of Analysis of Experimental Designs, Principles of Experimental Designs, Analysis of Variance for One- Way, Two -Way With One/M Observations Per Cell for Fixed and Random Effects Models, Post-Hoc Tests, Tukey's Test for Non-Additively.

Unit 3: Analysis of Completely Randomized Design, Randomized Block Design and Latin Square Designs. Missing Plot Techniques and their Analyses for Randomized Block Design and Latin Square Designs.

Unit 4: Analysis of Covariance for CRD and RBD, Factorial Experiments: Definition, Advantages, Yate's Method for of Computing Factor's Effect, Analysis of 2^2,$2^3$and 2^n Factorial Design, Confounding and Partial Confounding.

References:

1. Dass, M.N., & Giri, N.C. (2017). Design and Analysis of Experiments. New Age International.
2. Dey, A. (1987). Theory of Block Designs. Wiley–Blackwell.
3. Raghavrao, D. (2002). Construction and Combinatorial Problems in Design of Experiments. Dover Publications Inc.
4. Gupta, S.C., & Kapoor, V.K. (2014). Fundamentals of Applied Statistics. Sultan Chand & Sons.
5. Montgomery, D.C. (2013). Design and Analysis of Experiments. Wiley.
6. Goon, A.M., Gupta, M.K., & Gupta B.D. (2013). Outline of Statistical Theory Vol. II. World Press

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Design of Experiments (Practical)	**Course Code**	25STA203DS03
Hours per Week	2 Hours	**Credits**	1
Maximum Marks	25 {External (term-end exam) – 20} (Internal – 5)	**Time of Examinations**	1½ Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

Marks for Question Paper:	12
Marks for Practical Record Book:	05
Marks for Viva-Voce:	03
Total:	20

Course Learning Outcomes (CLO):

CLO 1: Students Acquired the Proficiency in Assessing the Appropriateness of Experimental Designs in Handling Extraneous Variables.

CLO 2: Students Acquired the Competence in Designing and Analyzing Experiments for Both One-Directional and Two-Directional Variations.

CLO 3: Students Acquired the Proficiency in the Analysis of Specific Experimental Designs such as CRD, RBD and LSD.

CLO 4: Students Acquired the Skill in Estimating Missing Observations and Subsequently Conducting a thorough Analysis of the Experimental Data.

CLO 5: Students Acquired the Profound Understanding of Treatment Allocation in Factorial Experiments with Two Levels and Adeptness in Analyzing Such Designs using Yate's Technique.

List of Practical's:

1. Calculate the BLUE for a Given Linear Model using the Method of Least Squares on a Dataset.
2. Compute the Variance-Covariance Matrix of BLUEs for a Set of Parameters using a Dataset.
3. Conduct ANOVA on a Dataset with One-Way Variation, Considering both Fixed and Random Effects Models.
4. Conduct Two-Way ANOVA with One Observation per Cell on a Dataset considering both Fixed and Random Effects Models.
5. Conduct Two-Way ANOVA with m Observation per Cell on a Dataset considering both Fixed and Random Effects Models.
6. Design and Analyze an Experiment Following the Principles of CRD using a Given Dataset.
7. Implement a Randomized Block Design and Perform the Corresponding Analysis on a Dataset.
8. Design and Analyze an Experiment using Latin Square Designs, Incorporating Missing Plot Techniques.
9. Apply ANCOVA to Analyze Datasets with Covariates in both CRD and RBD Setups.
10. Design and Analyze a 2^2, 2^3 Factorial Experiment for Exploring Interactions and Main Effects.

References:

1. Dass, M.N., & Giri, N.C. (2017). Design and Analysis of Experiments. New Age International.
2. Dey, A. (1987). Theory of Block Designs. Wiley–Blackwell.
3. Raghavrao, D. (2002). Construction and Combinatorial Problems in Design of Experiments. Dover Publications Inc.
4. Gupta, S.C., & Kapoor, V.K. (2014). Fundamentals of Applied Statistics. Sultan Chand & Sons.
5. Montgomery, D.C. (2013). Design and Analysis of Experiments. Wiley.
6. Goon, A.M., Gupta, M.K., & Gupta B.D. (2013). Outline of Statistical Theory Vol. II. World Press

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Multivariate Analysis	**Course Code**	25STA203DS04
Hours per Week	3 Hours	**Credits**	3
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Acquired the Knowledge to Deal with Multivariate Datasets

CLO 2: Students Acquired the Skill to Analyze the Multivariate Data with Mean Vector

CLO 3: Students Acquired the Ability to Test the Hypothesis for Means, Correlation and Regression Coefficients

CLO 4: Students Acquired the Ability to Find Major Factors and the Variability Using Multivariate Techniques including Principal Component Analysis, Factor Analysis, Discriminant and Cluster Analysis

CLO 5: Students Acquired the Knowledge to Judge the Situations Where Multivariate Analysis Techniques are Suitable in Different Environment

Unit 1: Multivariate Normal Distribution, Marginal and Conditional Distributions Characteristic Function, Distribution of Linear Combinations of Normal Vector, Random Sampling from a Multivariate Normal Distribution, Maximum Likelihood Estimators of Mean Vector and Covariance Matrix. Distribution of Sample Mean Vector, Distribution of Quadratic Forms.

Unit 2: Wishart Matrix - Its Distribution (Without Proof) and Properties. Distribution of Sample Generalized Variance, Null Distributions and Uses of Simple, Partial and Multiple Correlation Coefficients. Hotelling's T^2 Statistic –Derivation and Its Null distribution Uses of T^2 statistic, Behrens - Fisher's Problem.

Unit 3: Multivariate Linear Regression Model. Estimation of Parameters and Their Properties. Distribution of the Matrix of Sample Regression Coefficients, Test of Linear Hypothesis About Regression Coefficients, Multivariate Analysis of Variance [MANOVA] of One-Way Classified Data. Wilk's Lambda Criterion, Likelihood Ratio Test Criteria for Testing Independence of Sets of Variables.

Unit 4: Likelihood Ratio Criteria for Testing Equality of Covariance Matrices and Identity of Several Multivariate Normal Populations, Fisher's Discriminant Function, Discriminant Analysis, Mahalanobis' Distance, Factor Analysis and Cluster Analysis, Principal Components, Its Uses and Importance, Canonical Variables and Canonical Correlations.

References:

1. Anderson, T.W. (2009). An Introduction to Multivariate Statistical Analysis. Wiley.
2. Rao, C. R. (2002). Linear Statistical Inference and its Applications. Wiley.
3. Johnson, R. A. and Wichern, D. W. (2002). Applied Multivariate Statistical Analysis. Prentice Hall of India.
4. Rencher, A. C. (2002). Methods of Multivariate Analysis. John Wiley & Sons.
5. Muirhead, R.J. (2005). Aspects of Multivariate Statistical Theory. Wiley.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Multivariate Analysis (Practical)	**Course Code**	25STA203DS04
Hours per Week	2 Hours	**Credits**	1
Maximum Marks	25 {External (term-end exam) – 20} (Internal – 5)	**Time of Examinations**	1½ Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

Marks for Question Paper: 12
Marks for Practical Record Book: 05
Marks for Viva-Voce: 03
Total: 20

Course Learning Outcomes (CLO):

CLO 1: Students Acquired the Knowledge to Deal with Multivariate Datasets
CLO 2: Students Acquired the Skill to Analyze the Multivariate Data with Mean Vector
CLO 3: Students Acquired the Ability to Test the Hypothesis for Means, Correlation and Regression Coefficients
CLO 4: Students Acquired the Ability to Find Major Factors and the Variability Using Multivariate Techniques including Principal Component Analysis, Factor Analysis, Discriminant and Cluster Analysis
CLO 5: Students Acquired the Knowledge to Judge the Situations Where Multivariate Analysis Techniques are Suitable in Different Environment

List of Practical's:

1. Find Mean Vector and Variance Covariance Matrix for a Given Set of Data
2. Find Maximum Likelihood Estimate for Given Mean Vector and Covariance Matrix
3. Perform the Hypothesis Testing for Equality of Mean Vectors.
4. Estimate the Matrix of Regression Coefficients and Variance Covariance Matrix for Given Set of Vectors.
5. Perform the Linear Hypothesis about Regression Coefficients for Given Level of Significance
6. Carry Out Multivariate Analysis of Variance and Construct One Way MANOVA Table.
7. Compute Fisher's Discriminant Function for a Given Set of Vectors.
8. Find out Principal Components for Given Variance Covariance Matrix.
9. Calculate Mahalanobis' Distance for Given Set of Data.
10. Extract Factors from a Multivariate Data Set and Their Interpretation.
11. Perform Cluster Analysis to Discover Patterns and Groupings Within a Multivariate Dataset.
12. Find Canonical Variables and Canonical Correlations to Explore the Relationships between Different Sets of Variables in a Multivariate Dataset.

References:

1. Anderson, T.W. (2009). An Introduction to Multivariate Statistical Analysis. Wiley.
2. Rao, C. R. (2002). Linear Statistical Inference and its Applications. Wiley.
3. Johnson, R. A. and Wichern, D. W. (2002). Applied Multivariate Statistical Analysis. Prentice Hall of India.
4. Rencher, A. C. (2002). Methods of Multivariate Analysis. John Wiley & Sons.
5. Muirhead, R.J. (2005). Aspects of Multivariate Statistical Theory. Wiley.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Information Theory	**Course Code**	25STA203DS05
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Acquired Knowledge of Information Theory in Communication System.

CLO 2: Students Understand the concept of Entropy, Conditional Entropy, Joint Entropy, Information Measures and their Properties for Both Discrete and Continuous Case.

CLO 3: Students Attained the Ability to use Entropy Function in Noiseless Coding and Construction of Optimal Course.

CLO 4: Students Developed the Understanding of Channel Capacity and Decoding Scheme.

CLO 5: Students Acquainted with the Skills to Use Entropy Function in Statistics.

Unit 1: Basic Concepts of Information Theory, Measure of Uncertainty and Its Properties, Measure of Information for Two Dimensional Discrete and Continuous Finite Probability Scheme, Uniqueness of Entropy Function, Joint and Conditional Measure of Uncertainty, Interpretation of Uncertainty Measure, Measure of Mutual Information.

Unit 2: Noiseless Coding, Uniquely Decipherable Codes, Instantaneous Codes, Condition for Uniquely Decipherable and Instantaneous Codes, Noiseless Coding Theorem, Optimal Codes, Block Coding, Construction of Optimal Codes, Shannon Fano Encoding, Huffman Procedure.

Unit 3: Discrete Memoryless Channel, Channel Matrix, Channel Capacity, Classification of Channels, Channel Capacity for Different Types of Channel, Fundamental Theorem of Information Theory (without proof), Efficiency and Redundancy, Decoding Schemes, The Ideal Observer, Exponential Error Bound, Fano Inequality.

Unit 4: Inequalities of Information Theory, Kullback-Leibler Measure of Information, Mean Information for Discrimination and Divergence and Their Properties, Fisher Information, Information and Sufficiency, Minimum Discrimination Information-Sufficient Statistics.

References:

1. Ash, R.B. (2012): Information Theory. Dover Publications.
2. Reza, F.M. (2003): An Introduction to Information Theory. Dover Publications Inc.
3. Mathai, A.M. & Rathie, P.N. (1975): Basic Concepts in Information Theory and Statistics. Wiley Eastern Pvt. Ltd.
4. Kullback, S. (1997): Information Theory and Statistics. Dover Publications Inc.
5. Stone, J.V. (2015): Information Theory: A Tutorial Introduction, Sebtel Press.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Research Methodology	**Course Code**	25STA203SE01
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (Term-End Exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Understand Basic Concepts of Research and Its Methodologies.
CLO 2: Students Acquired the Knowledge of the Methodology for Writing a Research Project Proposal.
CLO 3: Students Understand Review of Literature.
CLO 4: Students Know the Scientific Misconducts.
CLO 5: Students Know the Quality of Research Publications.

Unit 1: Research Methodology: Introduction, Types and Significance of Research. Research Approaches. Research and Scientific Methods, Research Process, Research Problem and Criteria of Good Research, Features of a Good Research Design. Sampling Design: Characteristics of a Good Sample Design and Determination of Sample Size.

Unit 2: Documentation and Scientific Writing: Meaning & Techniques of Interpretation, Precautions in Interpretation, Preparation & Presentation of Manuscript of a Research Paper and Thesis Writing. Research Report: Presentation, Structure, Components, Types-Research Papers, Thesis, Research Project Report, Pictures & Graphs, Citation Styles and Bibliography.

Unit 3: Research Ethics: Ethics: Definition, Moral Philosophy, Nature of Moral Judgments and Reactions. Intellectual Honesty and Research Integrity, Scientific Misconducts: Falsification, Fabrication, and Plagiarism (FFP).

Publication Ethics: Definition, Introduction and Importance. Violation of Publication Ethics, Authorship and Contributorship, Predatory Publishers and Journals.

Unit 4: Databases: Indexing Databases, Citation Databases – Web of Science, Scopus, etc. Research Metrics: Impact Factor of Journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score. Metrics: h-Index, g-Index, i10 Index, Altmetrics.

References:

1. Kothari, C.R. (2004): Research Methodology (Methods and Techniques). New Age International.
2. Panneerselvam, R. (2013): Research Methodology. Prentice Hall India Learning Private Limited.
3. Bird, A. (2006). Philosophy of Science, Routledge
4. P. Chaddah (2018) Ethics in Competitive Research: Do Not Get Scooped; Do Not Get Plagiarised.
5. Anderson, J., Dursten, B.H. & Poole, M. (1989): Thesis and Assignment Writing. John Wiley & Sons.
6. Khanzode, V.V. (2003): Research Methodology (Techniques and Trends). Aph Publishing Corporation.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Reliability Theory	**Course Code**	25STA204DS01
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (Term-End Exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

Students:

CLO 1: Students Understand the Techniques of Reliability Prediction.

CLO 2: Students Acquired the Knowledge to Analyze Statistical Experiments Leading to Reliability Modeling.

CLO 3: Students Acquired the Ability to Apply Reliability Theory for the Assessment of Reliability in Engineering Design.

CLO 4: Students Acquainted with the Applications of Stochastic Processes in Reliability Theory.

CLO 5: Students Gained Knowledge to Develop System Reliability Models.

Unit 1: Reliability: Origin, Development and Importance of Reliability. Types of Reliability. Failures and Failure Modes. Causes of Failures. Failure Rate. Hazard Function. Reliability in Terms of Hazard Rate and Failure Density Functions. Hazard Models: Constant, Linear & Non-Linear, Weibull, Gamma and Normal Models. Markov Model. Estimation of Reliability and Failure Density Functions of Hazard and Markov Models. Mean Time to System Failure (MTSF). Relation Between MTSF and Reliability.

Unit 2: System and System Structures: Series, Parallel, Series-Parallel, Parallel-Series, Non-Series-Parallel, Mixed Mode and K-out-of-N. Evaluation of MTSF and Reliability of The System Structures. Determination of Reliability of Systems by Decomposition, Cut-Set, Event Space, Path Tracing and Boolean Function Methods.

Unit 3: Estimation of Reliability using Redundancy and Maintenance Techniques. Repairable and Non-Repairable Systems. Availability Functions. Estimation of Parametric and Non-Parametric Renewal Function. Renewal Theoretical Approach for Availability Evaluation of a System. Economics of Reliability Engineering: Manufactures & Customers Costs, Reliability Achievement, Utility and Depreciation Cost Models. Availability Cost Model for a Parallel System.

Unit 4: Markovian Approach for Estimation of Reliability and Availability of a Parallel-Unit System with Repair. Reliability and Availability Analysis: Single Unit System, Cold & Warm Standby Systems (Two-Units) and Parallel-Unit Systems with Arbitrary Distributions for Failure & Repair Rates and a Single Server using Semi-Markov Process & Regenerative Point Technique.

References:

1. Balagurusamy, E. (2017): Reliability Engineering. McGraw Hill Education.
2. Srinath, L.S. (2005): Reliability Engineering. East West.
3. Elsayed, E.A. (2012): Reliability Engineering. Wiley.
4. Birolini, A. (2007): Reliability Engg. (Theory and Practice). Springer.
5. Ebeling, C. (2017): An Introduction to Reliability and Maintainability Engineering. McGraw Hill Education.
6. Malik, S.C., Sinwar, D., Kumar, A., Gadde, S.R., Chatterjee, P., and Hung, B.T. (2023): Computational Intelligence in Sustainable Reliability Engineering, Wiley.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Econometrics	**Course Code**	25STA204DS02
Hours per Week	3 Hours	**Credits**	3
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Obtained Theoretical Background for the Standard Methods and Properties of OLS.

CLO 2: Students Acquired Knowledge About Regression Analysis for Analysing the Data.

CLO 3: Students Familiarized with Elementary Procedures for Model Validation in the Single Equation Context.

CLO 4: Students Gained the Knowledge of the Concept of Multicollinearity, Autocorrelation.

CLO 5: Students Acquainted with the Concepts of Non-Normality & Heteroscedasticity.

Unit 1: Basics of Econometrics, Two Variable Linear Regression Model- Least Squares Estimators of Coefficients and Their Properties, Inference in Least Squares Model, General Linear Regression Model, Least Squares Estimator and Its Properties, Inference In General Linear Regression Model. Generalized Least Squares Estimation.

Unit 2: Tests of Linear Restrictions On Regression Coefficients, Use of Extraneous Information On Regression Coefficients – Restricted Regression, Restricted Least Squares and Its Properties, Mixed Regression and Properties of Mixed Regression Estimator, Specification Errors Analysis- Inclusion and Deletion of Explanatory Variables, Effect On Estimation of Parameters and Disturbance Variance

Unit 3: Heteroscedasticity, Tests for Heteroscedasticity – Bartletts's, Breusch-Pagan and Goldfeld Quand t-Tests. Multicollinearity - Exact and Near Multicollinearity, Consequences and Detection of Multicollinearity, Farrar Glauber Test, Remedies for Multicollinearity, Ridge Regression Autocorrelation, Sources and Consequences, AR(1) Process Tests for Autocorrelation, Durbin-Watson Test, Errors in Variables Model, Instrumental Variable Method of Estimation.

Unit 4: Simultaneous Equations Models: Structural and Reduced Forms, Identification Problem. Rank and Order Conditions of Identification, Restrictions on Structural Parameters. Estimation in Simultaneous Equations Models: Recursive Systems, Indirect Least Squares 2SLS Estimators, Limited Information Estimators, K-Class Estimators.

References:

1. Johnston, J. (1984). Econometric Methods. McGraw-Hill, New York.
2. Gujarati, D. N. (2004). Basic Econometrics. Tata McGraw Hill.
3. Koutsyannis, A. (2004). Theory of Econometrics. Macmillan Publishers Limited
4. Maddala, G.S., & Lahiri, K. (2012). Introduction to Econometrics. Wiley.
5. Madnani, GMK. (2015). Introduction to Econometrics: Principles and Applications. Oxford & IBH Publishing Co. Pvt. Ltd.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Econometrics (Practical)	**Course Code**	25STA204DS02
Hours per Week	2 Hours	**Credits**	1
Maximum Marks	25 {External (term-end exam) – 20} (Internal – 5)	**Time of Examinations**	1½ Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

Marks for Question Paper:	12
Marks for Practical Record Book:	05
Marks for Viva-Voce:	03
Total:	20

Course Learning Outcomes (CLO):

CLO 1: Students Obtained Theoretical Background for the Standard Methods and Properties of OLS.
CLO 2: Students Acquired Knowledge About Regression Analysis for Analysing the Data.
CLO 3: Students Familiarized with Elementary Procedures for Model Validation in the Single Equation Context.
CLO 4: Students Gained the Knowledge of the Concept of Multicollinearity, Autocorrelation.
CLO 5: Students Acquainted with the Concepts of Non-Normality & Heteroscedasticity.

List of Practical's:

1. To Estimate the Coefficients of a Two-Variable Linear Regression for a Dataset.
2. Perform Hypothesis Testing and Construct Confidence Intervals for Parameters in a Two Variable Linear Regression Model using a Dataset.
3. To Estimate the Coefficients of a General Linear Regression Model for a Dataset.
4. Perform Hypothesis Testing and Construct Confidence Intervals for Parameters in a General Variable Linear Regression Model using a Dataset.
5. Implement Generalized Least Squares Estimation on a Dataset with Heteroscedasticity.
6. Conduct Tests on Linear Restrictions Imposed on Regression Coefficients using a Dataset.
7. Perform Analysis on Restricted Regression and Evaluate the Properties of Restricted Least Squares using Real Data.
8. Apply Bartlett's, Breusch-Pagan, and Goldfeld Quandt Tests to Detect Heteroscedasticity in a Dataset.
9. Identify Exact and Near Multicollinearity in a Multiple Regression and Use Farrar Glauber Test for its Detection.
10. Test for Autocorrelation using AR(1) Process Tests and Apply the Durbin-Watson Test on a Time-Series Dataset.
11. Address Errors in Variables in a Regression Model using Appropriate Techniques on a Dataset.
12. Estimate Structural and Reduced Forms in Simultaneous Equations Models using Recursive Systems and Various Estimation Techniques.

References:

1. Johnston, J. (1984). Econometric Methods. McGraw-Hill, New York.
2. Gujarati, D. N. (2004). Basic Econometrics. Tata McGraw Hill.
3. Koutsyannis, A. (2004). Theory of Econometrics. Macmillan Publishers Limited
4. Maddala, G.S., & Lahiri, K. (2012). Introduction to Econometrics. Wiley
5. Madnani, GMK. (2015). Introduction to Econometrics: Principles and Applications. Oxford & IBH Publishing Co. Pvt. Ltd.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Optimization Techniques	**Course Code**	25STA204DS03
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

Students:

CLO 1: Students Acquainted with the Formulation of the Real Life Problems as Linear Programming Problems.

CLO 2: Students Acquired the Skills to Use Techniques for Obtaining Optimal Solution of the Problems: of LPPs.

CLO 3: Students Attained the Ability to describe and formulate Non Linear Programming Problems (NLPP).

CLO 4: Students Understand the Difference between NLPP and LPP.

CLO 5: Students Acquainted with the Methods for the Solution of NLPP.

Unit 1: Linear Programming Problems: Formulation, Examples and Forms. Properties of a Solution to the LPP. Solution of LPP by Graphical and Simplex Methods. Solution of Simultaneous Equations by Simplex Method. Artificial Variable Techniques: Big-M-Method and Two Phase Simplex Method.

Unit 2: Degeneracy in LPP and its Resolution. The Revised Simplex Method. Duality in LPP: Symmetric and Un-Symmetric Dual Problems. Fundamental Duality Theorem. Complementary Slackness Theorem. Dual Simplex Method. Economic Interpretation of Duality. Post-Optimization Problems: Sensitivity Analysis and Parametric Programming.

Unit 3: Integer Programming Problems (IPP). Gomory's Algorithm for Pure Integer Linear Programs. Solution of IPP by Branch and Bound Method. Applications of Integer Programming. Non-Liner Programming Problems (NLPP): Formulation of NLPP. Kuhn-Tucker Necessary and Sufficient Conditions of Optimality, Graphical Solution of an NLPP.

Unit 4: Quadratic Programming Problems: Wolfe's and Beale's Method of Solutions. Dynamic Programming: Balman's Principle of Optimality. Application of Dynamic Programming in Production, Linear Programming and Reliability Problems.

References:

1. Gass, S.I. (2010). Linear Programming: Methods and Applications. Dover Publication.
2. Kambo, N.S. (1984). Mathematical Programming Techniques. Affiliated East-West Press.
3. Sinha, S.M. (2010). Mathematical Programming - Theory and Methods. Elsevier.
4. Bazaraa, M.S., Jarvis, J.J., & Sherali, H.D. (2011). Linear Programming and Network Flows. Wiley.
5. Hadley, G. (2002). Linear Programming. Narosa.
6. Bellman, R. (2003): Dynamic Programming. Dover Publications Inc.
7. Bellman, R.E., & Dreyfus, S.E. (2016): Applied Dynamic Programming. Princeton University Press.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Queuing Theory	**Course Code**	25STA204DS04
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

Students:

CLO 1: Students Understand Basic Characteristics of a Queuing System.

CLO 2: Students Attained Knowledge to Understand Probabilistic Models with Applications of Stochastic Processes in Solving Real Life Problems.

CLO 3: Students Abled to Analyze a Network of Queues with Poisson External Arrivals and Exponential Service Requirements.

CLO 4: Students Gained Knowledge to Formulate Stochastic Problems in Terms of Differential Equations and Their Steady State Solutions

CLO 5: Students Gained the Skills to Analyze Different Queuing Models with Single and Multiple Servers having Markovian and Non-Markovian Arrivals and Services

Unit 1: Queuing Process: Notations, Measures of Effectiveness and Characteristics, Little's Law, Applications of Poisson Process and Exponential Distribution. M/M/1 and M/M/I/R Models with Steady State Solution, Waiting Time Distribution, Measures of Effectiveness and Limited Waiting Space.

Unit 2: Parallel Channels Queues. M/M/C Model Steady State Solution, Waiting Time Distribution and with Limited Waiting Space. Queues with Parallel Channels of Truncation. M/M/C/K and M/M/∞ Models. Queues with Finite Waiting Capacity with Impatient Customers: Balking and Reneging. Machine Interference Problem.

Unit 3: Bulk System with Input and Output Service. Bulk Models: $M^{(x)}/M/1$, $M/M^{(y)}/1$, $M/M^{(a,b)}/1$, $M/E_K/1$and $E_K/M/1$ Steady State Solutions. Priority Queue Discipline. Networks of Queues, Open and Closed Queuing Networks, Queues with Vacations.

Unit 4: Non-Markovian Queues: Imbedded Markov Chain. M/G/1, G/M/1 and $M/G^{(a,b)}/1$ Models with Steady State Solutions. Supplementary Variables Technique: M/G/1 and $M/G^{(b)}/1$ Queuing Models.

References:

1. Gross, D., Shortle, J.F., Thompson, J.M., & Harris, C.M. (2013): Fundaments of Queuing Theory. Wiley.
2. Kashyap, B.R.K., & Chaudhary, M.L. (1988): An Introduction to Queuing Theory. A. & A. Publications.
3. Kleinrock, L. (1975): Queuing Systems. Wiley-Interscience.
4. Medhi, J. (1991): Stochastic Models in Queuing Theory. Academic Press Inc.
5. Cooper, R.B. (1981): Introduction to Queuing Theory. North Holland.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Actuarial Statistics	**Course Code**	25STA204DS05
Hours per Week	4 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students Understand Basic Characteristics of a Queuing System.

CLO 2: Students Attained Knowledge to Understand Probabilistic Models with Applications of Stochastic Processes in Solving Real Life Problems.

CLO 3: Students Abled to Analyze a Network of Queues with Poisson External Arrivals and Exponential Service Requirements.

CLO 4: Students Gained Knowledge to Formulate Stochastic Problems in Terms of Differential Equations and Their Steady State Solutions

CLO 5: Students Gained the Skills to Analyze Different Queuing Models with Single and Multiple Servers having Markovian and Non-Markovian Arrivals and Services

Unit 1: Introductory Statistics and Insurance Applications: Discrete, Continuous and Mixed Probability Distributions. Insurance Applications, Sum of Random Variables. Utility Theory: Utility Functions, Expected Utility Criterion, Types of Utility Function, Insurance and Utility Theory.

Unit 2: Principles of Premium Calculation: Properties and Its Examples, Individual Risk Models: Models for Individual Claims, Sum of Independent Claims, Approximations and their Applications. Compound Poisson Distribution and Its Properties. Principle of Compound Interest: Nominal and Effective Rates of Interest and Discount, Force of Interest and Discount, Compound Interest, Accumulation Factor, Continuous Compounding, Present Value of a Future Payment.

Unit 3: Survival Distribution and Life Tables: Uncertainty of Age at Death, Survival Function, Time Until-Death for a Person, Curate Future Lifetime, Force of Mortality, Life Tables with Examples, Deterministic Survivorship Group, Life Table Characteristics, Assumptions for Fractional Age, Some Analytical Laws of Mortality.

Unit 4: Life Insurance: Models for Insurance Payable at the Moment of Death, Insurance Payable at the End of the Year of Death and their Relationships. Life Annuities: Continuous Life Annuities, Discrete Life Annuities, Life Annuities with Periodic Payments. Premiums: Continuous and Discrete Premiums.

References:

1. Dickson, C.M.D. (2005). Insurance Risk and Ruin (International Series no. 1 Actuarial Science), Cambridge University Press
2. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A., & Nesbitt, C.J. (1997). Actuarial Mathematics. Society of Actuaries, Itasca, Illinois, U.S.A.
3. Rotar, V.I. (2015). Actuarial Models: The Mathematics of Insurance, 2nd ed., CRC Press, New York.
4. Promislow, S.D. (2011). Fundamentals of Actuarial Mathematics. Wiley.
5. Spurgeon, E.T. (2011). Life Contingencies, Cambridge University Press.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Regression Analysis Using SPSS	**Course Code**	25STA204SE01
Hours per Week	8 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The practical question paper will consist of seven questions and the students will be required to attempt any five questions. The question paper will be set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:

Marks for Question Paper:	45
Marks for Practical Record Book:	15
Marks for Viva-Voce:	10
Total:	70

Course Learning Outcomes (CLO):

CLO 1: Students Gained the Skills to Carry Out Simple, Multiple Linear Regressions in SPSS.
CLO 2: Students Developed the Ability to Perform Regression Analysis in SPSS.
CLO 3: Students Abled to Fit the Logistic and Poisson Regression Models in SPSS.
CLO 4: Students Acquainted with the Knowledge of the Concepts of Heteroscedasticity.
CLO 5: Students Gained the Ability to Deal with Multicollinearity and Autocorrelation.

List of Practicals:

1. Find the Best Fitted Line using the Method of Curve Fitting.
2. Fit the Simple Linear Regression and Assess the Significance of Obtained Model.
3. Fit the Multiple Linear Regression and Assess the Significance of Obtained Model.
4. Find the Best Fitted Regression Model using Backward Elimination &Forward Selection Criteria.
5. Fit Logistic Regression Model and Assess the Significance of Obtained Parameters.
6. Fit Poisson Regression Model and Assess the Significance of Obtained Parameters.
7. Test the Heteroscedasticity in the Data.
8. Test the Multicollinearity in the Data.
9. Fit Auto-Regressive and Moving Average Models of Autocorrelation.
10. Test Autocorrelation using Durbin Watson Test.
11. Test Model Adequacy Based on Regression Models.
12. Residual Analysis using QQ Plots and Histograms.
13. Evaluate the PRESS Statistic for Model Validation and Implementing Variance Stabilizing Transformations for Improved Model Performance.
14. Exploring Analytical Methods to Select Appropriate Transformations and Comparing the Effectiveness of Different Transformation Techniques.

References:

1. Gujarati, D. N. (2004): Basic Econometrics. Tata McGraw Hill.
2. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Pvt. Ltd., Kolkata.
3. Kapoor, J.N. & Saxena, H.C. (2020): Mathematical Statistics, Sultan Chand & Sons, Delhi.
4. Cunningham, B.J. (2012): Using SPSS: An Interactive Hands-on approach.
5. Field, A. (2013): Discovering Statistics Using SPSS, Fourth Edition, SAGE.

Name of Program	M.Sc. (Statistics)	**Program Code**	STA2
Name of the Course	Regression Analysis Using SPSS	**Course Code**	25STA204SE01
Hours per Week	8 Hours	**Credits**	4
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	3 Hours

Note: The practical question paper will consist of seven questions and the students will be required to attempt any five questions. The question paper will be set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:

Marks for Question Paper:	45
Marks for Practical Record Book:	15
Marks for Viva-Voce:	10
Total:	70

Course Learning Outcomes (CLO):

CLO 1: Students Gained the Skills to Carry Out Simple, Multiple Linear Regressions in SPSS.
CLO 2: Students Developed the Ability to Perform Regression Analysis in SPSS.
CLO 3: Students Abled to Fit the Logistic and Poisson Regression Models in SPSS.
CLO 4: Students Acquainted with the Knowledge of the Concepts of Heteroscedasticity.
CLO 5: Students Gained the Ability to Deal with Multicollinearity and Autocorrelation.

List of Practicals:

1. Find the Best Fitted Line using the Method of Curve Fitting.
2. Fit the Simple Linear Regression and Assess the Significance of Obtained Model.
3. Fit the Multiple Linear Regression and Assess the Significance of Obtained Model.
4. Find the Best Fitted Regression Model using Backward Elimination &Forward Selection Criteria.
5. Fit Logistic Regression Model and Assess the Significance of Obtained Parameters.
6. Fit Poisson Regression Model and Assess the Significance of Obtained Parameters.
7. Test the Heteroscedasticity in the Data.
8. Test the Multicollinearity in the Data.
9. Fit Auto-Regressive and Moving Average Models of Autocorrelation.
10. Test Autocorrelation using Durbin Watson Test.
11. Test Model Adequacy Based on Regression Models.
12. Residual Analysis using QQ Plots and Histograms.
13. Evaluate the PRESS Statistic for Model Validation and Implementing Variance Stabilizing Transformations for Improved Model Performance.
14. Exploring Analytical Methods to Select Appropriate Transformations and Comparing the Effectiveness of Different Transformation Techniques.

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1. Gujarati, D. N. (2004): Basic Econometrics. Tata McGraw Hill.
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3. Kapoor, J.N. & Saxena, H.C. (2020): Mathematical Statistics, Sultan Chand & Sons, Delhi.
4. Cunningham, B.J. (2012): Using SPSS: An Interactive Hands-on approach.
5. Field, A. (2013): Discovering Statistics Using SPSS, Fourth Edition, SAGE.

Dissertation/ Research Project (25STA204PD01)**:** Dissertation/Research Project will be carried out by each student of two-year PG Program during Second Year of 2-Year PG Program (Only for the students of IV semester opted Option 2 & for the students of III and IV Semesters opted Option 3) under the approved supervisor from among the faculty members of the department. The evaluation will be done jointly by the internal examiner and external examiner on the basis of Research Project Report/Dissertation and viva-voce. In case the supervisor of the student(s) shows his/her inability to act as internal examiner, the Head of the Department will work as internal examiner. The distribution of marks as follows:

1. Project Report/Dissertation Evaluation Marks – 350
2. Viva-Voce – 150