SYLLABI AND SCHEME OF EXAMINATIONS
FOR
DISCIPLINE SPECIFIC COURSES OF SINGLE MAJOR PROGRAM
B.Sc. (Statistics)

(Based on Curriculum and Credit Framework for UG Programs under NEP)

WITH EFFECT FROM THE SESSION 2024-25

MAHARSHI DAYANAND UNIVERSITY ROHTAK (HARYANA)

Credit Structure for Undergraduate Programmes (Single Major)

Semester	Discipline-Specific Courses (DSC) / Major Course	Minor(MIC)/ Vocational (VOC)/ Skill Enhancement Courses (SEC)/ Internship	Multidisciplinary courses (MDC)	Ability Enhancement courses (AEC)	Dissertation	Value-Added Courses (VAC)	Total Credits
I	DSC - A1 @ 4 credits DSC – A2 @ 4 credits	MIC1 @ 4 credits SEC1@ 3 credits	MDC1 @ 3 credits	AEC1 @ 2 credits	----------	VAC1 @ 2 credits	22
II	DSC – A3 @ 4 credits DSC – A4 @ 4 credits	MIC2 @ 4 credits SEC2@ 3 credits	MDC2 @ 3 credits	AEC2 @ 2 credits	----------	VAC2 @ 2 credits	22
Students exiting the programme after second semester and securing 48 credits including 4 credits of summer internship will be awarded UG Certificate in the relevant Discipline/Subject							
III	DSC – A5 @ 4 credits DSC – A6 @ 4 credits	MIC3 @ 4 credits SEC3@ 3 credits	MDC3 @ 3 credits	AEC3 @ 2 credits		VAC3 @ 2 credits	22
IV	DSC – A7 @ 4 credits DSC – A8 @ 4 credits DSC – A9 @ 4 credits DSC – A10 @ 4 credits	MIC4(VOC)@ 4 credits	----------	AEC4 @ 2 credits	----------	VAC4 @ 2 credits	24
Students exiting the programme after fourth semester and securing 94 credits including 4 credits of summer internship will be awarded UG Diploma in the relevant Discipline/Subject							
V	DSC – A11 @ 4 credits DSC – A12 @ 4 credits DSC – A13 @ 4 credits DSC – A14 @ 4 credits	MIC5(VOC)@ 4 credits Internship @ 4 credits#	----------	----------	----------	----------	24
VI	DSC – A15 @ 4 credits DSC – A16 @ 4 credits DSC – A17 @ 4 credits DSC – A18 @ 4 credits	MIC6(VOC)@ 4 credits SEC3@ 2 credits	----------	----------	----------	----------	22
Students will be awarded 3-year UG Degree in relevant major Discipline/Subject upon securing 136 credits.							
VII	DSC – H1 @ 4 credits DSC – H2 @ 4 credits DSC – H3 @ 4 credits DSC – H4 @ 4 credits DSC – H5 @ 4 credits	SEC4 @ 4 credits OR MIC7 (VOC) @ 4 credits OR Internship @ 4 credits	----------	----------	----------	----------	24
VIII (4yr UG Hon.)	DSC – H6 @ 4 credits DSC – H7 @ 4 credits DSC – H8 @ 4 credits DSC – H9 @ 4 credits DSC – H10 @ 4 credits	SEC5 @ 4 credits OR MIC8 (VOC) @ 4 credits OR Internship @ 4 credits	----------	----------	----------	----------	24
VIII (4yr UG Hon. with Research)	DSC – H6@ 4 credits DSC – H7@ 4 credits	SEC5 @ 4 credits OR MIC8 (VOC) @ 4 credits OR Internship @ 4 credits	----------	----------	Research project/ Dissertation @ 12 credits	---------- TOTAL CREDITS	24 184

Note: #Four credits of internship earned by a student during summer internship after 2nd semester or 4th semester will be counted in 5th semester of a student who pursue 3 year UG Programmes without taking exit option.

Discipline Specific Courses/ Major 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 - A1 @ 4 credits	Descriptive Statistics	24STAS401DS01	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC – A2 @ 4 credits	Probability Theory	24STAS401DS02	4	0	0	4	4	0	0	4	30	70	0	0	100
Semester II (Session 2024-25)															
DSC – A3 @ 4 credits	Probability Distributions	24STAS402DS01	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – A4 @ 4 credits	Survey Sampling	24STAS402DS02	3	0	1	4	3	0	2	5	25	50	5	20	100
Semester III (Session 2025-26)															
DSC – A5 @ 4 credits	Sampling Techniques	25STAS403DS01	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC – A6 @ 4 credits	Estimation Theory	25STAS403DS02	3	0	1	4	3	0	2	5	25	50	5	20	100
Semester IV (Session 2025-26)															
DSC – A7 @ 4 credits	Bio-Statistics	25STAS404DS01	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – A8 @ 4 credits	Statistical Programming Using Python	25STAS404DS02	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC – A9 @ 4 credits	Mathematical Techniques	25STAS404DS03	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – A10 @ 4 credits	Testing of Hypothesis	25STAS404DS04	3	0	1	4	3	0	2	5	25	50	5	20	100
Semester V (Session 2026-27)															
DSC – A11 @ 4 credits	Time Series Analysis	26STAS405DS01	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC – A12 @ 4 credits	Numerical Methods	26STAS405DS02	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – A13 @ 4 credits	Design of Experiments	26STAS405DS03	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC – A14 @ 4 credits	Financial Statistics	26STAS405DS04	4	0	0	4	4	0	0	4	30	70	0	0	100
Internship @ 4 credits	Project Work	26STAS405IN01	-	-	-	4	-	-	-	4	-	-	30	70	100

Semester VI (Session 2026-27)															
DSC – A15 @ 4 credits	Econometrics	26STAS406DS01	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC – A16 @ 4 credits	Economic Statistics	26STAS406DS02	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – A17 @ 4 credits	Official Statistics	26STAS406DS03	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – A18 @ 4 credits	Optimization Techniques-I	26STAS406DS04	4	0	0	4	4	0	0	4	30	70	0	0	100
Semester VII (Session 2027-28)															
DSC – H1 @ 4 credits	Machine Learning Using Python	27STAH407DS01	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC – H2 @ 4 credits	Operations Research	27STAH407DS02	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – H3 @ 4 credits	Statistical Quality Control	27STAH407DS03	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC – H4 @ 4 credits	Population Studies	27STAH407DS04	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – H5 @ 4 credits	Actuarial Statistics	27STAH407DS05	4	0	0	4	4	0	0	4	30	70	0	0	100
Semester VIII (Session 2027-28) (4 Year UG Hons.)															
DSC – H6 @ 4 credits	Real and Complex Analysis	27STAH408DS01	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – H7 @ 4 credits	Advanced Design of Experiments	27STAH408DS02	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – H8 @ 4 credits	Optimization Techniques-II	27STAH408DS03	4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – H9 @ 4 credits	Multivariate Analysis	27STAH408DS04	3	0	1	4	3	0	2	5	25	50	5	20	100
DSC – H10 @ 4 credits	DBMS and SQL	27STAH408DS05	3	0	1	4	3	0	2	5	25	50	5	20	100
Semester VIII (Session 2027-28) (4 Year UG Hons. with Research)															
DSC – H6 @ 4 credits	Any Two Papers from the Semester-VIII of 4 Year UG Hons.		4	0	0	4	4	0	0	4	30	70	0	0	100
DSC – H7 @ 4 credits			4	0	0	4	4	0	0	4	30	70	0	0	100
Research Project/ Dissertation @12 credits	Dissertation/ Research Project	27STA408PD01	-	-	-	12	-	-	-	12	-	-	100	200	300

L: Lecture; T: Tutorial; P: Practical

Note 1:

1. The minor papers will be offered to the students other than the students who opted Statistics as Major.
2. Multidisciplinary papers will be offered to the students who have not studied these papers at Higher Secondary Level (12^{th} Class) or have not opted major and minor stream under this category.
3. The Ability Enhancement Course (AEC) and Value Added Course (VAC) will be chosen by the students from the common pool provided by the Institute (University/College).
4. The students will undergo Summer Internships as per Scheme of Examination.
5. The students with UG with Honours/ UG Honours with Research will have to complete the Research Project/Dissertation as per the Scheme of the Examination.
6. Four Credits of Internship earned by a student during Summer Internship after 2^{nd} Semester or 4^{th} Semester will be counted in 5^{th} Semester of a student who pursue 3-Year UG Programme without taking exit options.

Note 2:

Internship: Internship is a course (called Project Report) requiring each student to participate in a professional activity or work experience or cooperative education activity with an entity external to the Institute (College) under the guidance of a faculty member (Supervisor) of the department and an expert of the given external entity. It involves working with local industry, government or private organizations, business organizations, artists, crafts persons and similar entities to provide opportunities for the student to actively engage in on-site experiential learning. The duration of the internship is of 120 hours for 04 credits during summer vacations i.e., after the end of semester exams. Each student shall submit the project report prepared during the Internship duly signed by the external entity and the supervisor. The project report is of 100 marks. The evaluation and assessment shall be done jointly by an external examiner and supervisor of the student (internal examiner) on the basis of quality, originality and innovativeness as well as significance of the outcomes of the project report. Further, in case the supervisor of the student shows his/her inability to act as internal examiner, the Head/Teaching In-charge of the Institution will work as internal examiner. The distribution of marks as follows:

1. Progress Report Marks Awarded by Entity Expert – 30
2. Project Report Evaluation Marks – 40
3. Viva-Voce – 30

Note 3:

Research Project/Dissertation will be carried out by each student of four year UG Hons. with Research program under the approved supervisor from among the faculty members of the department. The Research Project/Dissertation will be started in the VIII semester of the Program. 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/Teaching In-charge of the Institution will work as internal examiner. The distribution of marks as follows:

1. Research Project Report/Dissertation Evaluation Marks – 200
2. Viva-Voce – 100

Syllabi for Under Graduate Programme in Statistics

Semester: I

Session: 2024-25

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Descriptive Statistics	**Course Code**	24STAS401DS01
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75{External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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 of Statistics and Importance in Various Area

CLO 2: Students acquired the Knowledge to Represent Data in Tables and Graphs

CLO 3: Students acquired the Knowledge of Various Types of Data, Measures of Central Tendency and Dispersion

CLO 4: Students acquired the Knowledge of Correlation, Regression Diagnostics, Partial and Multiple Correlations

CLO 5: Students acquired the Knowledge of Independence and Association between Two Attributes

Unit 1: Meaning and Scope: Origin, Development and Definition of Statistics, Importance and Scope of Statistics, Limitations and Distrust of Statistics. Data: Primary and Secondary Data, Qualitative and Quantitative Data, Discrete and Continuous Data, Ungrouped and Grouped Data, Scales of Measurement - Nominal, Ordinal, Interval and Ratio, Tabular and Graphical Presentation of Data.

Unit 2: Measures of Central Tendency: Arithmetic Mean, Weighted Mean, Geometric Mean and Harmonic Mean, Median and Mode, Characteristics for an Ideal Measure of Central Tendency, Merits and Demerits of Measures of Central Tendency.

Unit 3: Measures of Dispersion: Range, Inter-quartile Range, Quartile Deviation, Mean Deviation, Standard Deviation (σ) and Root Mean Square Deviation, Coefficient of Variation, Measures of Skewness and Kurtosis, Characteristics for an Ideal Measure of Dispersion.

Unit 4: Analysis and Consistency of Categorical Data, Independence and Association of Attributes, Bi-variate Data: Scatter Diagram, Karl Pearson's Coefficient of Correlation, Spearman's Rank Correlation Coefficient, Principle of Least Squares and Fitting of Polynomials and Exponential Curves, Linear Regression, Partial and Multiple Correlation (Three Variables Only).

References:

1. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
2. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Private Limited, Kolkata.
3. Kapoor, J.N. and Saxena, H.C. (2020): Mathematical Statistics, Sultan Chand & Sons, New Delhi.
4. Ross, S.M. (2017): Introductory Statistics, Academic Press, Elsevier.
5. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2016): Fundamental of Statistics, Vol. I, The World Press Private Limited, Kolkata.
6. R. Vidya: Descriptive Statistics, NPTEL Swayam Portal

(URL: https://onlinecourses.swayam2.ac.in/cec21_ma01/preview)

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical(Descriptive Statistics)	**Course Code**	24STAS401DS01
Hours per Week	02 Hours	**Credits**	01
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 of Statistics and Importance in Various Area

CLO 2: Students acquired the Knowledge to Represent Data in Tables and Graphs

CLO 3: Students acquired the Knowledge of Various Types of Data, Measures of Central Tendency and Dispersion

CLO 4: Students acquired the Knowledge of Correlation, Regression Diagnostics, Partial and Multiple Correlations

CLO 5: Students acquired the Knowledge of Independence and Association between Two Attributes

List of Practicals:

1. Diagrammatic Representation of Statistical Data Problems Based on Simple and Subdivided Bar Diagrams, Pie Diagram.
2. Graphical Representation of Statistical Data.
3. Computation of Measures of Central Tendency and Dispersion. Use of an Appropriate Measure and Interpretation of Results.
4. Moments, Measures of Skewness and Kurtosis, Box Plot.
5. Consistency of Data up to Two Attributes. Concepts of Independence and Association of Two Attributes.
6. Yule's Coefficient of Association.
7. Bivariate Data: Scatter Diagram, Plotting and Interpretation.
8. Calculation of Product Moment Correlation Coefficient, Correlation Ratio, Rank Correlation.
9. Calculation of Regression Coefficients.
10. Fitting of Regression Lines by Least Squares.
11. Calculation of Partial and Multiple Correlation Coefficients for Three Variables

References:

1. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
2. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Private Limited, Kolkata.
3. Kapoor, J.N. and Saxena, H.C. (2020): Mathematical Statistics, Sultan Chand & Sons, New Delhi
4. Ross, S.M. (2017): Introductory Statistics, Academic Press, Elsevier.
5. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2016): Fundamental of Statistics, Vol. I, The World Press Private Limited, Kolkata.
6. R. Vidya: Descriptive Statistics, NPTEL Swayam Portal
   (URL: https://onlinecourses.swayam2.ac.in/cec21_ma01/preview)

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Probability Theory	**Course Code**	24STAS401DS02
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 the Knowledge about Random Variables, Probability Mass Function and Density Function
CLO 3: Students acquired the Knowledge to Understand Applications of Probability Theory in Real Life Problems
CLO 4: Students acquired the 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	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Probability Distribution	**Course Code**	24STAS402DS01
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 to Understand Probability Distributions
CLO 2: Students acquired the Knowledge of Practical Applications of Various Probability Distributions
CLO 3: Students acquired the Ability to Fit the Probability Distributions
CLO 4: Students acquired the Skill to Determine the Relationships between the Distributions
CLO 5: Students acquired the Knowledge of Computational Procedure of Various Statistical Properties of Probability Distributions

Unit 1: Discrete Distributions-I: Bernoulli, Binomial and Poisson Distributions: Functions and Properties such as Mean, Median, Mode, Variance, Standard Deviation, Moments up to Fourth Order, Moment Generating Function (M.G.F.), Cumulants up to Fourth Order, Cumulant Generating Function (C.G.F.), Probability Generating Function (P.G.F.), Characteristic Function (C.F.), Reproductive Property (Wherever Exists) and Their Real Life Applications, Poisson Approximation to Binomial Distribution.

Unit 2: Discrete Distributions-II: Uniform, Negative Binomial, Geometric, Hyper-Geometric Distributions: Functions and Properties such as Mean, Median, Mode, Variance, Standard Deviation, Moments up to Fourth Order, M.G.F., Cumulants up to Fourth Order, C.G.F., P.G.F., C.F., Reproductive Property (Wherever Exists) and Their Real Life Applications, Lack of Memory Property for Geometric Distribution, Poisson Approximation to Negative Binomial Distribution, Binomial Approximation to Hyper-Geometric Distribution.

Unit 3: Continuous Distributions-I: Rectangular, Exponential, Normal Distributions and Gamma Distribution: Functions and Properties such as Mean, Median, Mode, Variance, Standard Deviation, Moments up to Fourth Order, M.G.F., Cumulants up to Fourth Order, C.G.F., P.G.F., C.F., Reproductive Property (Wherever Exists) and Their Real Life Applications, Normal Distribution as a Limiting Case of Binomial and Poisson Distributions.

Unit 4: Continuous Distributions-II: Beta First & Second Kind and Cauchy Distributions: Functions and Properties (Wherever Exists) such as Mean, Median, Mode, Variance, Standard Deviation, Moments up to Fourth Order, M.G.F., Cumulants up to Fourth Order, C.G.F., P.G.F., C.F., Reproductive Property (Wherever Exists) and Their Real Life Applications. Sampling Distributions: Chi-Square, Student's t, Snedecor's F, Fisher's-Z with Their Applications.

References:
1. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2016): Fundamental of Statistics, Vol. I, The World Press Private Limited, Kolkata.
3. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Private Limited, Kolkata.
4. Gupta, K.R. (2014): Statistics Volume – II, Atlantic Publisher, New Delhi.
5. Misra, N: Probability and Distributions, NPTEL Swayam Portal (URL: https://archive.nptel.ac.in/courses/111/104/111104032/)

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Survey Sampling	**Course Code**	24STAS402DS02
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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 Knowledge to Understand the Schemes of Systematic Sampling
CLO 5: Students attained the Skill to Identify the Possible Bias in the Sample and How to Deal with These Biases

Unit 1: Basic Concepts: Population, Sample, Parameter and Statistic. Sampling Versus Census, Advantages of Sampling Methods, Role of Sampling Theory, Sampling and Non-Sampling Errors, Bias and Its Effects, Probability and Non-Probability Sampling.

Unit 2: Simple Random Sampling With and Without Replacement, Use of Random Number Tables in Selection of Sample, Estimation of Population Mean and Variance, Derivation of Expression for Variance of These Estimates, Sample Size Determination.

Unit 3: Stratified Random Sampling: Problem of Allocation, Proportional Allocation, Optimum Allocation, Derivation of the Expression for the Standard Errors of the Usual Estimators when these Allocations are used.

Unit 4: Gain in Precision due to Stratification, Construction of Strata and Determination of Number of Strata. Systematic Sampling: Estimation of Population Mean and Population Total, Standard Errors of these Estimators.

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	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical (Survey Sampling)	**Course Code**	24STAS402DS02
Hours per Week	02 Hours	**Credits**	01
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 Knowledge to Understand the Schemes of Systematic Sampling
CLO 5: Students attained the Skill to Identify the Possible Bias in the Sample and How to Deal with These Biases

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.

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	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Sampling Techniques	**Course Code**	25STAS403DS01
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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 Achieved skills to Use the Techniques for Conducting Sample Surveys
CLO 2: Obtained Knowledge about the Sampling Scheme including Simple Random, Stratified, Systematic, Double and Cluster Samplings
CLO 3: Students Gained the ability to Identify or Control the Sampling and Non-Sampling Errors
CLO 4: Students Achieved Knowledge to Use of Auxiliary Information for Estimation of the Parameters
CLO 5: Students Acquired the knowledge to Generate the Random Sample using Different Methods

Unit 1: Concepts of Census and Sample Surveys: Basic Concepts in Sampling, Sampling and Non-Sampling Errors, Principal Steps Involved in a Sample Survey, Bias, Precision, Accuracy and Mean Squared Error, Limitation of Sampling, Basic Principle of Sampling Survey, Types of Sampling, Selection of a Simple Random Sample: Lottery and Random Number Methods.

Unit 2: Simple Random Sampling With and Without Replacement, Estimation in Simple Random Sampling, Merits and Demerits of SRS, Estimation of Population Proportion for Attributes, Determination of Sample Size in SRS, Ratio and Regression Estimators: Use of Auxiliary Information, Ratio Estimator, Bias of Ratio Estimator, Unbiased Ratio Type Estimator, Regression Estimator, Bias in the Linear Regression Estimator.

Unit 3: Double Sampling (Two-Phase Sampling), Stratified Random Sampling: Principal Advantages of Stratified Random Sampling, Allocation of Sample Size, Optimum Allocation, Cost Function, Relative Precision Between Stratified Random and Simple Random Sampling.

Unit 4: Systematic Sampling: Linear and Circular, Advantages of Systematic Sampling over Simple Random Sampling Cluster Sampling: Single Stage, Two Stage, Principal Advantages of Two Stage Sampling, Estimation of Population Mean and Variance, Comparison of Two Stage Sampling with Single Stage 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.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical (Sampling Techniques)	**Course Code**	25STAS403DS01
Hours per Week	02 Hours	**Credits**	01
Maximum Marks	25 {External (term-end exam) – 20} (Internal – 5)	**Time of Examinations**	03 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 Achieved skills to Use the Techniques for Conducting Sample Surveys

CLO 2: Obtained Knowledge about the Sampling Scheme including Simple Random, Stratified, Systematic, Double and Cluster Samplings

CLO 3: Students Gained the ability to Identify or Control the Sampling and Non-Sampling Errors

CLO 4: Students Achieved Knowledge to Use of Auxiliary Information for Estimation of the Parameters

CLO 5: Students Acquired the knowledge to Generate the Random Sample using Different Methods

List of Practical's:

1. To Select a SRS With and Without Replacement.
2. For a Population of Size 5, Estimate Population Mean, Population Mean Square and Population Variance. Enumerate All Possible Samples of Size 2 by WR & WOR
3. For SRSWOR, Estimate Mean, Standard Error and the Sample Size
4. In SRSWR, Show that the Sample Mean Variance are an Unbiased Estimator of Population Mean and Variance Respectively.
5. Determination of Sample Size in SRS.
6. Stratified Random Sampling with Proportional and Optimum Allocation
7. Systematic Sampling with N= nk. Comparison of Systematic Sampling with Stratified
8. Estimate the Gain in Precision Due to Stratification
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.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Estimation Theory	**Course Code**	25STAS403DS02
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (Term-End exam) – 50} (Internal – 25)	**Time of Examinations**	03 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, Pitmen Family, Minimum Variance Unbiased (MVU) Estimators.

Unit 2: Mean-Squared Error, Fisher's Information Measure, Cramer-Rao Inequality, Minimum Variance Bound (MVB) Estimators, Bhattacharya's Bounds, Rao-Blackwell Theorem, Lehman Schefe's Theorem and its Applications in Finding Uniformly Minimum Variance Unbiased Estimators.

Unit 3: Methods of Estimation: Maximum Likelihood, Moments, Least Square, Minimum Chi-Square and Modified Minimum Chi-Square and Their Properties. Fisher's Information Matrix-Simultaneous of Parameters in Normal (Univariate and Bivariate) Distribution.

Unit 4: 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. Likelihood Ratio Test: Derivation and Its Properties, Asymptotic Distribution of L.R. 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.
Casella, G., & Berger, R.L. (2006). Statistical Inference. Cengage

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical (Estimation Theory)	**Course Code**	25STAS403DS02
Hours per Week	02 Hours	**Credits**	01
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 Practicals:

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.

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.
   Casella, G., & Berger, R.L. (2006). Statistical Inference. Cengage

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Bio-Statistics	**Course Code**	25STAS404DS01
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) –70} (Internal – 30)	**Time of Examinations**	03 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 Proficiency in Biostatistical Concepts Including Data Types, Scales of Measurement and Scaling Techniques such as Z-scores and T-scores
CLO 2: Students Acquired the Expertise of Test Reliability Assessment Such as Test-Retest, Parallel, Split-Half and Cronbach's Alpha, Ensuring the Validity and Consistency of Assessment Tools
CLO 3: Students Acquired the Competence in Accurately Measure the Occurrence of Diseases Using Morbidity Indicators such as Prevalence and Incidence Rates
CLO 4: Students Acquired the Ability to Assess the Validity & Reliability of Diagnostic and Screening Tests
CLO 5: Students Acquired the Proficiency in Estimating Risks Including Absolute Risk, Relative Risk, Odds Ratio and Attributable Risk

Unit 1: Introduction to Biostatistics, Data and Its Types, Scales of Measurement, Scaling: Z-Scores and Z-Scaling. Standard Score and T-Scores. Reliability of Test Scores: Test-retest, Parallel, Split Half and Cronbach's Alpha Methods.

Unit 2: Measuring the Occurrence of Disease, Measures of Morbidity - Prevalence and Incidence Rate, Association Between Prevalence and Incidence, Uses of Prevalence and Incidence, Problems with Incidence and Prevalence Measurements. Clinical Agreement: Kappa Statistic, Mantel-Haenszel Test, Intra-Class Correlation.

Unit 3: Assessing the Validity and Reliability of Diagnostic and Screening Test: Validity of Screening Test – Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value, Reliability, Relationship between Validity and Reliability. ROC Curve and its Applications.

Unit 4: Issues in Epidemiology: Association, Causation. Causal Inference, Errors and Bias, Confounding, Measurement of Interactions. Generalizability Estimating Risk: Estimating Association. Estimating Potential for Prevention: Attributable Risk. Comparison of Relative and Attributable Risks. Odds Ratios for Retrospective Studies, Odds Ratios Approximating the Prospective Risk Ratio. Exact Inference for Odds Ratio Analysis of Matched Case-Control Data.

References:

1. Bernard, H.R., (1995): Research Methods in Anthropology: Qualitative and Quantitative Approaches, Altamira Press, Walnut Creek.
2. Goode, W.J. and Hatt P.K. (1952): Methods in Social Research. McGraw Hills, New York.
3. Pullum, W. (2006): An Assessment of Age and Data Reporting in the DHS Surveys 1985-2003. DHS Methodological Report No. 5. Calverton, Maryland, Marco International Inc.
4. Royce, A.S. and Bruce, C.S. (1999): Approaches to Social Research, Oxford, Oxford University Press.
5. Young, P.V. (1994): Scientific Social Surveys and Research. Prentice-Hall, New York(4th Edition).
   Altman, D.G. (2006): Practical Statistics for Medical Research, London: Chapman and Hall.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Statistical Programming Using Python	**Course Code**	25STAS404DS02
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75{External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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 Able to Understand the Syntax of the Programming.
CLO 2: Students Acquired Knowledge to Create and Read the Formatted Files.
CLO 3: Students Acquainted with the Methods to Handle the Redundancy Complexity.
CLO 4: Students Achieved the Knowledge of OOP Used in Data Modeling.
CLO 5: Students Obtained the Skills for Testing of Hypothesis using Python

Unit 1: Introduction to Python, Installing Python, Basic Syntax, Interactive Shell, Editing, Saving and Running a Script, Concept of Data Types, Variables, Assignments, Numerical Types, Arithmetic Operators and Expressions, Comments in the Program, Understanding Error Messages, Control Statements, if-else, Loops (for and while).

Unit 2: Strings, Text Files: String Manipulations: Subscript Operator, Indexing, Slicing a String; Strings and Number System: Converting Strings to Numbers and Vice Versa. Binary, Octal, Hexadecimal Numbers. Text Files: Reading/Writing Text and Numbers from/to a File, Creating and Reading a Formatted File (csv or tab-separated)..

Unit 3: Lists, Dictionary and Design with Functions: Basic list Operators, Replacing, Inserting, Removing an Element; Searching and Sorting Lists; Dictionary Literals, Adding and Removing Keys, Accessing and Replacing Values; Traversing Dictionaries. Hiding Redundancy, Complexity; Arguments and Return Values; Program Structure and Design. Recursive Functions.

Unit 4: Object Oriented Concepts: Classes and OOP: Classes, Objects, Attributes and Methods; Defining Classes; Design with Classes, Data Modelling; Persistent Storage of Objects, Inheritance, Polymorphism.
Hypothesis Testing: z-Test, One Sample t-Test, Two Sample t-Test, Paired Sample t-Test, Chi-Square Goodness of Fit and One-Way Analysis of Variance.

References:
1. Zhang.Y., (2016): An Introduction to Python and Computer Programming, Springer Publications,
2. Vander Plas Jake (2016): ,Python Data Science Handbook - Essential Tools for Working with Data, O'Reily Media,Inc,
3. Guttag John V, (2013): Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press
4. Sedgewick Robert, Wayne Kevin, (2016): Introduction to Programming in Python: Dondero Robert, An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd.,
5. Joel Grus, (2016): Data Science from Scratch First Principles with Python, O'Reilly Media.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical (Statistical Programming Using Python)	**Course Code**	25STAS404DS02
Hours per Week	02 Hours	**Credits**	01
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 Able to Understand the Syntax of the Programming.
CLO 2: Students Acquired Knowledge to Create and Read the Formatted Files.
CLO 3: Students Acquainted with the Methods to Handle the Redundancy Complexity.
CLO 4: Students Achieved the Knowledge of OOP Used in Data Modeling.
CLO 5: Students Obtained the Skills for Testing of Hypothesis using Python

List of Practical's:

1. Create a Simple Python Script with Basic Syntax.
2. Execute Python Commands in an Interactive Shell.
3. Declare Variables of Different Data Types (int, float, str).
4. Perform Basic Arithmetic Operations using Numerical Variables.
5. Explore the Concept of Data Types and Variable Assignments.
6. Write a Program using if-else Statements to Determine Whether a Number is Even or Odd.
7. Implement for Loop to Print a Sequence of Numbers.
8. Create a While Loop for a Basic Counting Application.
9. Read and Write Text to a File using Python.
10. Handle Different Number Systems (binary, octal, hexadecimal) in Python.
11. Create and Read a Formatted CSV file.
12. Create a Dictionary, Add and Remove Key-Value Pairs.
13. Traverse through a Dictionary and Perform Operations.
14. Explore Dictionary Literals and Manipulation.
15. Implement a z-test for a Sample Dataset.
16. Conduct a One-Sample t-test in Python.
17. Perform a Two-Sample t-test and Paired Sample t-test.
18. Use Python for Chi-Square Goodness of Fit and One-Way Analysis of Variance.

References:

1. Zhang.Y., (2016): An Introduction to Python and Computer Programming, Springer Publications,
2. Vander Plas Jake (2016): ,Python Data Science Handbook - Essential Tools for Working with Data, O'Reily Media,Inc,
3. Guttag John V, (2013): Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press
4. Sedgewick Robert, Wayne Kevin, (2016): Introduction to Programming in Python: Dondero Robert, An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd.,
5. Joel Grus , (2016): Data Science from Scratch First Principles with Python, O'Reilly Media.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Mathematical Techniques	**Course Code**	25STAS404DS03
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70}(Internal – 30)	**Time of Examinations**	03 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 of Matrix Algebra and Its Applications.
CLO 2: Students Achieved Skills for Computing Eigen Values and Eigenvectors of Linear Transformations.
CLO 3: Students Gained the Knowledge of Reducing Quadratic Forms to their Canonical Form.
CLO 4: Students Attained the Ability to Apply Differential Calculus Concepts to Solve Problems involving Limits, Continuity, and Partial Differentiation.
CLO 5: Students Acquired the Proficiency in Evaluating Integrals using Various Techniques.

Unit 1: Matrix and Its Types, Algebra of Matrices, Orthogonal Matrix, Singular and Non-Singular Matrices and Their Properties, Trace of a Matrix, Determinants, Adjoint and Inverse of a Square Matrix, Involutory, Unitary, Idempotent and Nilpotent Matrices, Rank of a Matrix.

Unit 2: Linear and Orthogonal Transformation of a Matrix. Eigen Values and Eigen Vectors of a Linear Transformation. Quadratic Forms and Their Reduction to Canonical Form. Signature of a Matrix. Positive Definite Matrix.

Unit 3: Differential Calculus: Differential Function, Limits of Function, Continuous Functions, Partial Differentiation and Total Differentiation. Indeterminate Forms: L-Hospital's Rule, Leibnitz Rule for Successive Differentiation. Euler's Theorem on Homogeneous Functions. Maxima and Minima of Functions of One and Two Variables, Constrained Optimization Techniques (with Lagrange multiplier) Along with Some Problems. Jacobian, Concavity and Convexity, Points of Inflexion of Function, Singular Points.

Unit 4: Integral Calculus: Definite and Indefinite Integrals, Differentiation under Integral Sign, Double Integral, Change of Order of Integration, Transformation of Variables. Beta and Gamma Functions: Properties and Relationship Between them.

References:

1. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International, 1997.
2. Gupta S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons, 2008.
3. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition -1997).
4. Gorakh Prasad: Integral Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition -2000).
5. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Testing of Hypothesis	**Course Code**	25STAS404DS04
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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 of Various Sampling Distributions.
CLO 2: Students Gained The Knowledge of Basic Concepts of Hypothesis Testing.
CLO 3: Students Gained The Ability To Apply Large & Small Sample Tests.
CLO 4: Students Acquainted With Skills to Construct Confidence Intervals For Various Parameters.
CLO 5: Students Acquired the Skills to Apply the Hypothesis Testing of One Sample and Two Samples for Location Problem.

Unit 1: Population, Sample, Parameter, Statistic, Standard Error, Central Limit Theorem, Sampling Distribution: Student's t-Distribution, F-Distribution, χ^2-Distribution: Definitions, Properties and Their Applications.

Unit 2: Concepts of Statistical Hypothesis, Null and Alternative Hypotheses, Critical Region, Type of Errors, Level of Significance and Power of the Test. One and Two Tailed Tests.
Large Sample Tests and Confidence Intervals for Single Mean and Difference of Two Means, Single Proportion, Difference of Proportions. Standard Deviation and Correlation Coefficient.

Unit 3: Small Sample Tests and Confidence Intervals for Single Mean, Difference of Means and Paired Sample. χ^2-test for Goodness of Fit and Independence of Attributes. F-test for Equality of Variances, One Way and Two Way ANOVA.

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, Kruskal Wallis Test and Friedman Test.

References:
1. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
2. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Private Limited, Kolkata.
3. Ross, S.M. (2017): Introductory Statistics, Academic Press, Elsevier.
4. Siegel, S., & Castellan, N.J. (1988). Nonparametric Statistics for Behavioral Sciences. McGraw-Hill Education.
5. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2016): Fundamental of Statistics, Vol. I, The World Press Private Limited, Kolkata.
6. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2016): Fundamental of Statistics, Vol. II, The World Press Private Limited, Kolkata.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical (Testing of Hypothesis)	**Course Code**	25STAS404DS04
Hours per Week	02 Hours	**Credits**	01
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 of Various Sampling Distributions.
CLO 2: Students Gained The Knowledge of Basic Concepts of Hypothesis Testing.
CLO 3: Students Gained The Ability To Apply Large & Small Sample Tests.
CLO 4: Students Acquainted With Skills to Construct Confidence Intervals For Various Parameters.
CLO 5: Students Acquired the Skills to Apply the Hypothesis Testing of One Sample and Two Samples for Location Problem.

List of Practical's:

1. Perform Various Test to Check the Normality of a Dataset.
2. Use the t-distribution to Calculate Confidence Intervals for a Given Dataset and Understand Its Application in Hypothesis Testing.
3. Use the z-distribution to Calculate Confidence Intervals for a Given Dataset and Understand Its Application in Hypothesis Testing.
4. Explore the F and $\chi 2$ Distributions to Calculate Confidence Intervals for a Given Dataset and Understand Its Application in Hypothesis Testing.
5. Implement One Way and Two Way Analysis of Variance (ANOVA) to Compare Means across Multiple Groups.
6. Compare the Median of a Single Sample to a Known Value or Test the Difference between Paired Observations using Wilcoxon Signed Rank Test.
7. Compare the Distributions of Two Independent Samples using Mann Whitney Test.
8. Compare the Distributions of Three or More Independent Samples using Kruskal Wallis Test.
9. Test the Association between Two Categorical Variables using Chi-Square Test.
10. Compare Three or More Matched Groups (Repeated Measures) When the Dependent Variable is Ordinal Using Friedman Test.

References:

1. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
2. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Private Limited, Kolkata.
3. Ross, S.M. (2017): Introductory Statistics, Academic Press, Elsevier.
4. Siegel, S., & Castellan, N.J. (1988). Nonparametric Statistics for Behavioral Sciences. McGraw-Hill Education.
5. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2016): Fundamental of Statistics, Vol. I, The World Press Private Limited, Kolkata.
6. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2016): Fundamental of Statistics, Vol. II, The World Press Private Limited, Kolkata.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Time Series Analysis	**Course Code**	26STAS405DS01
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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 Foundational Knowledge and Understanding of Time Series Analysis.
CLO 2: Students Acquired Skills to Measure and Analyze the Cyclic Component of Time Series Data using Methods such as Harmonic and Periodogram Analysis.
CLO 3: Students Acquired The Comprehensive Understanding of the Concept of Stationary Time Series
CLO 4: Students Acquired The Ability to Implement Box-Jenkins Models and Estimate Parameters in ARIMA Models.
CLO 5: Students Acquired The Knowledge and Skills for Spectral Analysis of Time Series Data in the Frequency Domain.

Unit 1: Introduction to Time Series and Its Applications, Components of a Time Series, Decomposition of Time Series. Trend & Its Types of Estimation, Measurement of Seasonal Fluctuations: Method of Simple Averages, Ratio to Trend Method, Ratio to Moving Average Method, Link Relative Method.

Unit 2: Measurement of Cyclic Component: Harmonic and Periodogram Analysis, Variate Difference Method and its Uses. Concept of Stationary Time Series: Strong and Weak Stationary, Types of Stationarity, Augmented Dickey-Fuller Test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS), Auto Covariance & Auto Correlation and their Properties. Correlogram of Moving Average and Auto Regressive Schemes.

Unit 3: Box-Jenkins Models, Estimation of Parameters in ARIMA Models, Estimation of the Parameters of AR(1) and AR(2) – Yule-Walker Equations. Forecasting: Exponential and Adaptive Smoothing Models and Holt Winter's Method, Holt Winter Method's for Multi-Seasonality.

Unit 4: Spectral Analysis: Time Series in Frequency Domain, Spectral Density, Periodogram and Discrete Fourier Transforms, Estimation of Spectral Density, Multiple Series and Cross Spectra, Linear Filters.

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.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical (Time Series Analysis)	**Course Code**	26STAS405DS01
Hours per Week	02 Hours	**Credits**	01
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 Foundational Knowledge and Understanding of Time Series Analysis.
CLO 2: Students Acquired Skills to Measure and Analyze the Cyclic Component of Time Series Data using Methods such as Harmonic and Periodogram Analysis.
CLO 3: Students Acquired The Comprehensive Understanding of the Concept of Stationary Time Series
CLO 4: Students Acquired The Ability to Implement Box-Jenkins Models and Estimate Parameters in ARIMA Models.
CLO 5: Students Acquired The Knowledge and Skills for Spectral Analysis of Time Series Data in the Frequency Domain.

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. Estimate the Parameters of AR(1) and AR(2) Models using Yule-Walker Equations. Discuss the Implications of Different Parameter Values on the Time Series Behaviour.
11. Implement Exponential Smoothing Models for Forecasting Time Series data.
12. Estimate the Spectral Density of a Given Time Series using Appropriate Techniques.

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.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Numerical Methods	**Course Code**	26STAS405DS02
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 Proficiency in Solving Linear Algebraic Equations using Numerical Methods.
CLO 2: Students Acquired The Understanding of the Concept of Consistency in Linear Systems of Equations and be Able to Apply Appropriate Methods to Solve Consistent and Inconsistent Systems
CLO 3: Students Acquired The Skills in Solving Non-linear Equations using Numerical Methods
CLO 4: Students Acquired The Skills in Numerical Differentiation using Newton's Differentiation Formulas and Various Numerical Integration Techniques
CLO 5: Students Acquired The Practical Skills to Apply Numerical Methods in Solving Real-World Mathematical Problems

Unit 1: Solution of linear Algebraic Equations: Introduction, Consistency of a Linear System of Equations, Gaussian Elimination Method, Gauss-Jordan Method, Inverse of Matrix using Gauss Elimination Method, Method of Factorization, Iterative Methods(Jacobi & Gauss-Seidel Iteration), Power Method..

Unit 2: Solution of Non-linear Equations: The Bisection Method, The Method of False Position, Newton-Raphson Method, Solution of System of Nonlinear Equation, Fixed Point Iteration and Convergence.
Interpolation and Approximation: Introduction, Errors in Polynomial Interpolation, Lagrange's Polynomials, Newton's Interpolation using Difference and Divided Differences, Cubic Spline Interpolation, Least Squares Method for Linear and Non-linear Data. Correlation and their Properties. Correlogram of Moving Average and Auto Regressive Schemes.

Unit 3: Numerical Differentiation and Integration: Introduction to Numerical Differentiation, Newton's Differentiation Formulas, Numerical Integration (Trapezoidal Rule, Simpson's 1/3 rule, 3/8 rule) and Romberg Integration.

Unit 4: Laplace and Inverse Laplace Transforms: Definitions and Basic Properties. Convolution Theorem. Applications of Laplace Transforms to the Solution of Linear Ordinary Differential Equations, Partial Differential Equations and Integral Equations.

References:
1. Burden, R.L. and Faires J.D. (2011): Numerical Analysis, 9th Ed., Boston: Cengage Learning.
2. Chopra, S.C. and Raymond, P.C. (2010): Numerical Methods for Engineers, New Delhi: Tata McGraw-Hill.
3. Gerald, C.F. and Wheatley, P.O. (2009): Applied Numerical Methods, 7th Ed., New York: Pearson Education.
4. Milton, J. and Ohira, T. (2014): Mathematics as a Laboratory Tool: Dynamics, Delays and Noise, Springer-Verlag New York.
5. Grewal, B.S. (2013): Numerical Methods in Engineering and Science. 11th Edition, Khanna Publishers.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Design of Experiments	**Course Code**	26STAS405DS03
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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 Analysing 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 Analysing 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	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical (Design of Experiments)	**Course Code**	26STAS405DS03
Hours per Week	02 Hours	**Credits**	01
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 Analysing 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 Analysing 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.

Semester: V

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Financial Statistics	**Course Code**	26STAS405DS04
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 to distinguish between deterministic and random cash flows and grasp the basic theory of interest
CLO 2: Students Acquired the Ability to Analyze and Optimize Investment Portfolios.
CLO 3: Students Understand Forward Contracts, Spot Price, Future Price, and the basics of Call and Put Options.
CLO 4: Students Acquainted with the Skill to Apply Arbitrage Relations, Understand Binomial and Trinomial Models, and Explore Pricing in Perfect Financial Markets.
CLO 5: Students Proficient in Understanding Black-Scholes Differential Equation, Formulae for European and American Options, Implied Volatility, and Hedging Strategies.

Unit 1: Introduction to Investment and Markets: Cash Flows- Deterministic and Random, Basic Theory of Interest, Bonds and Yields, Term Structure of Interest Rates, Portfolio Theory.

Unit 2: Introduction to Derivatives, Tools Needed for Option Pricing: Forward Contracts, Spot Price, Forward Price, Future Price, Call and Put Options, Zero-Coupon Bonds and Discount Bonds, Pricing Derivatives: Arbitrage Relations and Perfect Financial Markets, Pricing Futures, Put-Call Parity for European and American Options, Relationship between Strike Price and Option Price. Discrete Stochastic Processes, Binomial Processes, General Random Walks, Geometric Random Walks, Binomial Models, Trinomial Models.

Unit 3: Continuous Time Processes – Brownian Motion, Geometric Brownian Motion, Wiener Process; Introduction to Stochastic Calculus: Stochastic Integration, Stochastic Differential Equations and Their Solutions and Itô's Lemma.

Unit 4: Intrinsic of Option Markets: Black-Scholes Differential Equation, Black-Scholes Formula for European and American Options, Implied Volatility, Binomial Model for European Options: Cox-Ross-Rubinstein Approach to Option Pricing. Discrete Dividends, Trinomial Model for American Options, Hedging Portfolios: Delta, Gamma and Theta Hedging.

References:

1. Franke, J., Hardle, W.K. and Hafner, C.M. (2011): Statistics of Financial Markets: An Introduction, 3rd Edition, Springer Publications.
2. Stanley L. S. (2012): A Course on Statistics for Finance, Chapman and Hall/CRC.
3. David, G. L. (2015). Investment Science, Oxford University Press (South Asian Edition)
4. Lindstrom, E., Madsen, H. and Nielsen, J.N. (2020): Statistics for Finance. CRC Press.
5. Rachev, S.T., Hochstotter, M., Fabozzi, F.J. and Focardi, S.M. (2010): Probability and Statistics for Finance. Wiley.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Econometrics	**Course Code**	26STAS406DS01
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical(Econometrics)	**Course Code**	26STAS406DS01
Hours per Week	02 Hours	**Credits**	01
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.

Semester: VI

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Economic Statistics	**Course Code**	26STAS406DS02
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 Knowledge to Differentiate between Normative and Positive Economics.
CLO 2: Students Gained the Analytical Skills to Apply the Principles of Individual Decision-Making, Economic Interactions, and Trade-Offs.
CLO 3: Students Acquired the Knowledge to Apply Indices of Development and Learn Methods for Estimating National Income using Different Approaches.
CLO 4: Students Got the Skills to Analyse Laws of Demand and Supply, Exploring Price and Supply Elasticity of Demand.
CLO 5: Students Proficient in Constructing and Utilizing Index Numbers for Measuring Price, Quantity, and Value Relatives.

Unit 1: Scope and Method of Economics, Microeconomics and Macroeconomics, Normative Economics and Positive Economics. Principles of Microeconomics: Principles of Individual Decision Making and Principles of Economic Interactions – Introduce Trade off, Opportunity Cost, Efficiency, Marginal Changes and Cost-Benefit, Trade, Market Economy, Property Rights, Market Failure, Externality and Market Power. Interdependence and the Gains from Trade- Production Possibilities Frontier and Increasing Costs, Absolute and Comparative Advantage and Gains from Trade.

Unit 2: Economic Development, Growth in Per Capita Income and Distributive Justice, Indices of Development; Human Development Index, Estimation of National Income - Product Approach, Income Approach and Expenditure Approach; Measuring Inequality in Incomes, Poverty Measurement - Measures of Incidence and Intensity Combined.

Unit 3: Demand Analysis – Laws of Demand and Supply, Price and Supply Elasticity of Demand. Partial and Cross Elasticity of Demand. Income Elasticity of Demand. 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, Laspeyer's, Paasche's, Marshall–Edge Worth 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.

References:

1. Oresi, S.N. (2019): Micro and Macro Economics: Understanding the Basics of Economics. New Generation Publishing
2. Goon, A.M., Gupta, M.K., & Gupta B.D. (2016). Fundamentals of Statistics, Vol-II. World Press.
3. Gupta, S.C., & Kapoor, V.K. (2014). Fundamental of Applied Statistics. Sultan Chand and Sons, New Delhi.
4. Mukhopadhyay, P. (2018). Applied Statistics. Books and Allied (P) Ltd.
5. Croxton, F.E., & Cowden, D.J. (1942). Applied General Statistics. Prentice-Hall, Inc.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Official Statistics	**Course Code**	26STAS406DS03
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 Gained Knowledge About the Functioning of Various Statistical Agencies.
CLO 2: Students Acquainted with the Knowledge of Structures, Data Collection Methods of Major Statistical Agencies.
CLO 3: Students Trained in Methods Used by Agencies and Methods to Overcome the Obstacles in this Process.
CLO 4: Students Gained Knowledge About the Different Official Statistical Publications of World and India.
CLO 5: Students Acquainted with the Knowledge and Needs of the Various Statistical Agencies around the World and their Importance.

Unit 1: Introduction to Indian and International Statistical Systems: Role, Function. Introduction to Official Statistics: Needs, Uses, Reliability, Relevance, Limitations, Transparency, Collection and Compilation. Methods of Collection of Official Statistics & their Reliability and Limitations, Agencies Involved, General and Special Data Dissemination Systems.

Unit 2: National Statistical Organization: Vision and Mission, Roles and Responsibilities, Important Activities and Principal Publications. National Statistical Commission: Needs, Constitution, its Role and Functioning, Legal Acts/Provisions/Support for Official Statistics and Important Acts. National Income/GNP, Purchasing Power Parity: Needs, Methods of Calculation, Usages, Reliability, Draw Backs.

Unit 3: Sector wise Statistics: Environment, Health, Education, Women & Child Welfare: Important Surveys and Census by NSSO, Labour Bureau and RBI, Indicators, Agencies Involved, Uses and Principal Publications Containing such Statistics. National Accounts: Definition, Basic Concepts, Issues, Strategies, Functioning, Collection of Data and Release, Principal Publications.

Unit 4: Population Census: Needs, Data Collected, Periodicity, Methods of Data Collection, Dissemination, Agencies Involved in Population Census, Different publications of Population Census Data. Merits and Demerits. Office of Registrar General: Historical Prospective, Structure, Functions and Features, Responsibilities. Agricultural Census: Objectives, Features and Methods of Data Collection, Utility of Census, Merit and Demerits, Principal Publications.

References:
1. Saluja, M.R. (1972). Indian Official Statistical Systems, Statistical Pub. Society.
2. Saluja, M.R. (2017). Measuring India: The Nation's Statistical System, OUP India.
3. Statistical System in India, CSO (MOSPI) Publication.
4. Handbook of Statistics for the Indian Economy, RBI(various years).
5. Economic Surveys, Govt. of India, Ministry of Finance (various years).

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Optimization Techniques-I	**Course Code**	26STAS406DS04
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 the Importance of Extreme Points in Obtaining the Optimal Solution.
CLO 2: Students Acquainted with the Formulation of the Real Life Problems as Linear Programming Problems.
CLO 3: Students Acquired the Skills to Use Techniques for Obtaining Optimal Solution of the Problems of LPPs.
CLO 4: Students Acquired Knowledge for Achieving Optimal Solutions of the Transportation and Assignment Problems.
CLO 5: Students Acquainted the Ability for Determining Alternate Solutions of the LPP.

Unit 1: Convex Sets and Functions. Linear Programming Problems: Formulation, Examples and Forms. Properties of a Solution to the LPP. Development of Optimum Feasible Solution. Solution of LPP by Graphical and Simplex Methods. Solution of Simultaneous Equations by Simplex Method.

Unit 2: Artificial Variable Techniques: Big-M-Method and Two Phase Simplex Method. 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.

Unit 3: Post-Optimization Problems: Sensitivity Analysis and Parametric Programming. Integer Programming Problems (IPP). Gomory's Algorithm for Pure Integer Linear Programs. Solution of IPP by Branch and Bound Method. Applications of Integer Programming.

Unit 4: Transportation Problems: Mathematical Formulation and Fundamental Properties. Initial Basic Feasible Solution by North West Corner Rule, Lowest Cost Entry Method and Vogel's Approximation Method. Optimal Solution of Transportation Problems. Assignment Problems: Mathematical Formulation, Reduction Theorem and Solution by Hungarian Assignment Method.

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.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Machine Learning Using Python	**Course Code**	27STAH407DS01
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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 about Implementing the Conditional Statements to Control the Flow of a Python Program.
CLO 2: Students Attained the Ability to Perform EDA Using Data Frames, Handle Missing Values and Visualize Data.
CLO 3: Students Got the Skills to Identify, Handle and Troubleshoot Errors in Python Programs.
CLO 4: Students Acquired the Knowledge about Binary Logistic Regression, Decision Tree Classifier and KNN Classification.
CLO 5: Students Acquired the Understanding about Support Vector Machine for Classification Tasks.

Unit 1: Python Programming: Introduction to Python, Declaring Variables, Conditional Statements, Generating Sequence Numbers, Loops, Functions, List, Tuples, Set, Dictionary, Dealing with Strings, Map, Filter and Reduce, Modules and Packages. Comments in the Program, Errors and Exceptions, Handling Exceptions, Modules

Unit 2: Introduction to Machine Learning, Real-World Applications of Machine Learning, and Types of Machine Learning: Supervised, Unsupervised and Semi-Supervised, Python Libraries for Machine Learning: PANDAS, NUMPY, SCIKIT-LEARN, MATPLOTLIB.
Exploratory Data Analysis: Working with Data Frames, Handling Missing Values, Data Exploration Using Visualization.

Unit 3: Supervised Learning: Simple and Multiple Linear Regression, Steps in Building a Regression Model, Model Building, Model Diagnostics, Classification Overviews, Binary Logistic Regression, Model Building: Model Diagnostics, Creating Confusion Matrix, Gain Chart and Lift Chart, Classification Tree, Building Decision Tree Classifier using Gini Criteria. Gini Impurity, Benefits of Decision Tree, KNN Classification, Support Vector Machine.

Unit 4: Unsupervised Learning: Clustering Techniques - K-means Clustering and Hierarchical Clustering, Forecasting: Moving Average, Exponential Smoothing, AR Models, Moving Average Processes, ARMA Model, ARIMA Model and their Diagnostics..

References:

1. Bishop, C.M. (2016): Pattern Recognition and Machine Learning, Springer.
2. James, G., Witten, D., Hastie, T. and Tibshirani, R. (2017): Introduction to Statistical Machine Learning with Applications in R, Springer.
3. Tom, M. (2017): Machine Learning, McGraw Hill Education, New York.
4. Kulkarni, P. (2012): Reinforcement and Systemic Machine learning for Decision Making, Wiley-IEEE Press.
5. Pradhan M. & Kumar, U.D. (2019): Machine Learning using Python, Wiley.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical (Machine Learning Using Python)	**Course Code**	27STAH407DS01
Hours per Week	02 Hours	**Credits**	01
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 about Implementing the Conditional Statements to Control the Flow of a Python Program.

CLO 2: Students Attained the Ability to Perform EDA Using Data Frames, Handle Missing Values and Visualize Data.

CLO 3: Students Got the Skills to Identify, Handle and Troubleshoot Errors in Python Programs.

CLO 4: Students Acquired the Knowledge about Binary Logistic Regression, Decision Tree Classifier and KNN Classification.

CLO 5: Students Acquired the Understanding about Support Vector Machine for Classification Tasks.

List of Practicals:

1. Write a Program to Declare Variables of Different Types (Int, Float, String).
2. Write a Program Using If, Else and Elif Statements.
3. Create a Program to Generate a Sequence of Random Numbers.
4. Write a Program to Implement For, While and Nested Loops in Python.
5. Write a Program to Define and Call Functions with Different Parameters.
6. Write a Program to Perform Operations on these Data Structures, such as Appending, Slicing and Updating.
7. Write a Program Manipulate Strings, Concatenate them and use String Methods.
8. Write a Program to apply Map, Filter, and Reduce Functions on Lists.
9. Write a Program to Add Comments for Code, Intentionally Introduce Errors and Handle Exceptions.
10. Explore Python Libraries for Machine Learning.
11. Perform Exploratory Data Analysis (EDA) for a Given Dataset
12. Write a Program for Simple and Multiple Linear Regression Models using a Dataset.
13. Write a Program to Build a Binary Logistic Regression Model using a Dataset.
14. Write a program to Build a Decision Tree Classifier using Gini Criteria on a Dataset.
15. Write a Program to Implement K-Nearest Neighbour and SVM Classifiers on Dataset.
16. Write a Program to Perform K-Means and Hierarchical Clustering on a Dataset.
17. Write a Program to Implement Moving Average, Exponential Smoothing, AR Models and ARIMA Models on a Dataset.

References:

1. Bishop, C.M. (2016): Pattern Recognition and Machine Learning, Springer.
2. James, G., Witten, D., Hastie, T. and Tibshirani, R. (2017): Introduction to Statistical Machine Learning with Applications in R, Springer.
3. Tom, M. (2017): Machine Learning, McGraw Hill Education, New York.
4. Kulkarni, P. (2012): Reinforcement and Systemic Machine learning for Decision Making, Wiley-IEEE Press.
5. Pradhan M. & Kumar, U.D. (2019): Machine Learning using Python, Wiley.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Operations Research	**Course Code**	27STAH407DS02
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 Ability to Take Optimum Decisions/Solution to the Executive Type Problems.
CLO 2: 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 3: Students Achieved the Ability to Solve Job Sequencing Problem of N Jobs through 2, 3 and M Machines.
CLO 4: Students Acquired the Ability to Use Process of Simulation in Inventory, Queuing, Finance etc.
CLO 5: Students Acquired the Understanding to Use CPM and PERT Methods in Effective Project Management.

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 Labeling 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	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Statistical Quality Control	**Course Code**	27STAH407DS03
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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 Importance of Quality Control in Maintaining Product/Service Standards.
CLO 2: Students Gained the Ability to Assess and Interpret Process Capability Measures.
CLO 3: Students Gained Hands-on Experience in Creating and Interpreting Control Charts.
CLO 4: Students Proficient in Designing and Evaluating Sampling Plans.
CLO 5: Students Understand the Six Sigma Methodologies for Process Improvement.

Unit 1: Concept of Quality, Quality Characteristics, Concept of Quality Control, Quality Control Methodology, Statistical Methods of Quality Control. Statistical Quality Control and Its Purposes, 3 Sigma Control Limit, Shewart's Control Chart. Control Charts for Variables and Attributes, Natural Tolerance Limits and Specification Limits: Modified Control Limits.

Unit 2: Sampling Inspection Plan, Producer's and Consumer's Risk OC and ASN Function, AQL. LTPD and ATI. Concept of Process Capability, Measures of Process Capability, Potential Process Capability, actual Process Capability, Process Capability Analysis. Moving Average Control Chart, Cumulative Sum Control Chart, Exponentially Weighted Moving Average Control Chart.

Unit 3: 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.

Unit 4: Acceptance Sampling by Variables (Known and Unknown Sigma Case). Concept of Six Sigma, methods of Six Sigma, DMAIC Methodology, DFSS Methodology, Six Sigma Control Chart, Case Studies.

References:
1. Goon, A.M., Gupta, M.K., & Gupta B.D. (2016). Fundamentals of Statistics, Vol-II. World Press.
2. Croxton, F.E., & Cowden, D.J. (1942). Applied General Statistics. Prentice-Hall, Inc.
3. Gupta, S.C., & Kapoor, V.K. (2014). Fundamental of Applied Statistics. Sultan Chand and Sons, New Delhi.
4. Grant, E.L. (1946). Statistical Quality Control. McGraw Hill.
5. Montgomery, D.C. (2008). Introduction to Statistical Quality Control. John Wiley and Sons.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical (Statistical Quality Control)	**Course Code**	27STAH407DS03
Hours per Week	02 Hours	**Credits**	01
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 Understand the Importance of Quality Control in Maintaining Product/Service Standards.
CLO 2: Students Gained the Ability to Assess and Interpret Process Capability Measures.
CLO 3: Students Gained Hands-on Experience in Creating and Interpreting Control Charts.
CLO 4: Students Proficient in Designing and Evaluating Sampling Plans.
CLO 5: Students Understand the Six Sigma Methodologies for Process Improvement.

List of Practicals:

1. To Develop and Interpret the $\bar{X}$ *and* R chart for a Manufacturing Process.
2. Construct and Interpret the $\bar{X}$ *and* σ chart for a Manufacturing Process
3. Construct and Interpret Control Chart for Fraction Defective.
4. Construct and Interpret the Control Chart for the Non-Conforming Unit for Per Unit.
5. To Develop the Operating Characteristic (OC) Curves and Average Total Inspection (ATI) Curves, Average Outgoing Quality Limit (AOQL) for Simple Sampling Plan.
6. To Develop the Operating Characteristic (OC) Curves and Average Total Inspection (ATI) Curves, Average Outgoing Quality Limit (AOQL) for Double Sampling Plan.
7. To Implement and Analyze a Sequential Sampling Plan for Quality Control and Interpret the OC, AOQL, ATI and AOQ.
8. Construct and Interpret Process Capability Ratios.
9. Construct and Interpret Cumulative Sum and Exponentially Weighted Moving Average Control Chart.
10. Design and Utilize Six Sigma Control Charts for Monitoring and Improving Processes.
11. Implement the Define-Measure-Analyze-Improve-Control (DMAIC) Methodology in a Practical Quality Control Context.

References:

1. Goon, A.M., Gupta, M.K., & Gupta B.D. (2016). Fundamentals of Statistics, Vol-II. World Press.
2. Croxton, F.E., & Cowden, D.J. (1942). Applied General Statistics. Prentice-Hall, Inc.
3. Gupta, S.C., & Kapoor, V.K. (2014). Fundamental of Applied Statistics. Sultan Chand and Sons, New Delhi.
4. Grant, E.L. (1946). Statistical Quality Control. McGraw Hill.
5. Montgomery, D.C. (2008). Introduction to Statistical Quality Control. John Wiley and Sons.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Population Studies	**Course Code**	27STAH407DS04
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 Acquainted with the Understanding of the Historical Development and Scope of Population Studies.
CLO 2: Students Gained the Skills to Apply Various Measures for the Assessment of Mortality.
CLO 3: Students Acquired the Knowledge of Construction and Uses of a Life Tables.
CLO 4: Students Gained the Ability to Apply Various Measures for the Assessment of Mortality
CLO 5: Students Familiarized with the Methods of Population Projection.

Unit 1: History, Definition, Nature and Scope of Population Studies, Relationship of other Social Sciences with Population Studies, Social Structure, Social and Racial Groups, Society and Culture and Its Role in Population Studies, Social Institutions (Family, Marriage, Kinship, and Religion) and Their Role in Influencing Population Studies, Social Change in India, Tribes in India and Their Culture.

Unit 2: 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 And Merrill's Method. Greville's Method, Chiang's Method.

Unit 3: 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.

Unit 4: 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.

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. Bhende A.A. & Kanitkar T. (2010): Principles of Population Studies, Himalaya Publishing House, India.
4. Saluja, M.R. (2017). Measuring India: The Nation's Statistical System, OUP India.
5. Biswas, S., & Sriwastav G.L. (2014). Stochastic Processes in Demography and Applications. New Central Book Agency.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Actuarial Statistics	**Course Code**	27STAH407DS05
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 of Basic Actuarial Models.
CLO 2: Students Acquired Skills for the Applying the Methods of Actuarial Science in Insurance and Risk Management
CLO 3: Students Provided Ample Scope for Employment in the Insurance and Financial Sectors
CLO 4: Students Acquainted with the Applications of Statistics and Probability in Insurance, Pension Plans and Other Investment Areas
CLO 5: Students Gained the Knowledge of Reserve Benefits

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	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Real and Complex Analysis	**Course Code**	27STAH408DS01
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 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 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	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Advanced Design of Experiments	**Course Code**	27STAH408DS02
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 Learned the Issues and Principles for Orthogonal Latin Square (OLS).
CLO 2: Students Attained the Ability to Analyze the Balanced Incomplete Block designs (BIBD).
CLO 3: Students Attained the Ability to Analyze the Partially Balanced Incomplete Block designs (PBIBD).
CLO 4: Students Acquainted with Confounding in Different Experiments.
CLO 5: Students Acquired Knowledge of Designs for Fitting Response Surfaces.

Unit 1: General Block Designs: C - Matrix and its Properties Latin Squares and Orthogonal Latin Square (OLS), Upper bound for the Number of OLS. Construction of Complete Sets of Mutually Orthogonal Latin Square (MOLS). Construction of BIBD using MOLS.

Unit 2: Partially Balanced Incomplete Block designs. Definition and Relation between the Parameters. Association Matrices, its Algebraic Properties Classification of two Associate Class PBIB Designs. Applications of PBIBD.

Unit 3: Concept of Confounding. Confounding in 2^n Experiments. Complete and Partial Confounding in Symmetric Factorial Experiments. Split and Strip Plot Designs

Unit 4: Galois Fields, Quadratic Residues, Hadamard Matrices, Plackett Burman Designs and their Properties, Orthogonal Arrays and their Constructions, Designs for Fitting Response Surfaces, Design Criterion Involving Bias and Variance.

References:

1. Dey, A. (1987): Theory of Block Designs. Wiley–Blackwell.
2. Raghavrao, D. (2002): Construction and Combinatorial Problems in Design of Experiments. Dover Publications Inc.
3. Dass, M.N. & Giri, N.C. (2017): Design and Analysis of Experiments. New Age International.
4. Hedayat, A.S., Sloane, N.J.A. & Stufken, J. (1999): Orthogonal Arrays: Theory and Applications. Springer.
5. Myers, R.H., Montgomery, D.C. & Anderson-Cook, C.M. (2009): Response Surface Methodology: Process and Product Optimization using Designed Experiments. Wiley–Blackwell.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Optimization Techniques-II	**Course Code**	27STAH408DS03
Hours per Week	04 Hours	**Credits**	04
Maximum Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 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 for the Solutions of Games by LPP Techniques.
CLO 2: Students Attained the Ability to describe and formulate Non Linear Programming Problems (NLPP).
CLO 3: Students Understand the Difference between NLPP and LPP.
CLO 4: Students Acquainted with the Methods for the Solution of NLPP.
CLO 5: Students Obtained Approximate Solutions of Restricted Problems.

Unit 1: Theory of Games: Characteristics of Games, Minimax (Maximin) Criterion and Optimal Strategy. Solution of Games with Saddle Point. Equivalence of Rectangular Game and Linear Programming. Fundamental Theorem of Game Theory. Solution of m x n Games by Linear Programming Method. Solution of 2 X 2 Games Without Saddle Point. Principle of Dominance. Graphical Solution of (2 x n) and (m x 2) Games.

Unit 2: Non-Liner Programming Problems (NLPP): Formulation of NLPP. Kuhn-Tucker Necessary and Sufficient Conditions of Optimality, Graphical Solution of an NLPP. Quadratic Programming Problems: Wolfe's and Beale's Method of Solutions.

Unit 3: Separable Programming and Its Reduction to LPP. Separable Programming Algorithm. Geometric Programming: Constrained and Unconstrained. Complementary Geometric Programming Problems. Fractional Programming and its Computational Procedure.

Unit 4: Dynamic Programming: Bellman's Principle of Optimality. Application of Dynamic Programming in Production, Linear Programming and Reliability Problems. Goal Programming and its Formulation. Stochastic Linear Programming.

References:

1. Kambo, N.S. (1984): Mathematical Programming Techniques. Affiliated East-West Press.
2. Sinha, S.M. (2010): Mathematical Programming - Theory and Methods. Elsevier.
3. Bellman, R. (2003): Dynamic Programming. Dover Publications Inc.
4. Bellman, R.E., & Dreyfus, S.E. (2016): Applied Dynamic Programming. Princeton University Press.
5. Mitra, G. (1976): Theory & Applications of Mathematical Programming. Academic Press Inc.

Name of Program	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Multivariate Analysis	**Course Code**	27STAH408DS04
Hours per Week	03 Hours	**Credits**	03
Maximum Marks	75 {External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 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: 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, Beheran - 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	B.Sc. (Statistics)	**Program Code**	USSTA4
Name of the Course	Practical (Multivariate Analysis)	**Course Code**	27STAH408DS04
Hours per Week	02 Hours	**Credits**	01
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: 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 Practicals:

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.