DDU GORAKHPUR UNIVERSITY, GORAKHPUR

DEPARTMENT OF MATHEMATICS AND STATISTICS

National Education Policy-2020

Syllabus

of

STATISTICS

(Effective from Academic Session 2024-2025)

For

UG Four Year Programme

(UG Honors/UG Honors with Research)

UG Four Year Programme

(UG Honors/UG Honors with Research)

For Statistics based on National Education Policy-2020 in Choice Based Credit System (CBCS)

The proposed curriculum is expected to provide the students a good overall knowledge of science covering various aspects. They will not only be able to understand the important techniques but also able to apply some commonly used techniques to other fields.

The course of UG Four Year Programme (UG Honors/UG Honors with Research) For Statistics will be spread in four years – 1st, 2nd, 3rd and 4th Year. Each of which will have two semester examinations and therefore will be eight semester examinations.

Subject Prerequisites

To study this subject a student must had the subject(s) Mathematics in class 12th.

Eligibility for Admission

For UG in Statistics following candidates are eligible for admission.
Eligibility for admission in this course, a student must have the subject Mathematics in class 12th.

Program Duration

The duration of the UG Four Year Programme (UG Honors/UG Honors with Research) For Statistics the candidates admitted in semester, I will be of four academic years (8 semesters). There are two regular semesters in an academic year.

Examination and Assessment

As prescribed by the University (as per common ordinance for examination and assessment).

Programme Objectives

The UG Four Year Programme (UG Honors/UG Honors with Research) For Statistics aims to provide:

a) In-depth knowledge in Statistics through understanding of key statistical concepts, principles, theories and their applications.

b) inculcate strong interest in learning mathematics.

c) evolve broad and balanced knowledge and understanding of definitions, key concepts, principles and theorems in Statistics.

d) enable learners/students to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problems in statistics.

e) develop in students the ability to apply relevant tools developed in statistical theory to handle issues and problems in social and natural sciences.

f) provide students with sufficient knowledge and skills that enable them to undertake further studies in statistics and related disciplines.

g) sufficient subject matter competence and enable students to prepare for various competitive examinations such as IIT-JAM, GATE, GRE, UGC-CSIR, NET/JRF and Civil Services Examinations etc.

Framework of Four Year UG Programme (UG Honors)

Year	Sem.	Major1 (Subject-1) Statistics			Major 2 (Subject-2) From Same Faculty	Minor (Subject- 3) From Same/ Other Faculty	SEC/ Vocational	AEC/ CoCurricular	Dissertation/ Research Project/ Field Work/ Survey	Total	Award Degree
		Course Code	Course Title	Credits	Credits	Credits	Credits	Credits	Credits		
1	I	STAT- 101F	Descriptive Statistics (Univariate) and Theory of Probability	4	6	6	3	2	---	23	Certificate in Faculty (46 Credits)
		STAT- 102F	Descriptive Data Analysis Lab (Univariate)	2							
	II	STAT- 103F	Descriptive Statistics (Bivariate) and Probability Distributions	4	6	6	3	2	---	23	
		STAT- 104F	Descriptive Data Analysis Lab (Bivariate)	2							
2	III	STAT- 201F	Theory of Estimation and Sampling Survey	4	6	6	3	2	---	23	Diploma in Faculty (92 Credits)
		STAT- 202F	Sampling Survey Lab	2							
	IV	STAT- 203F	Testing of Hypothesis and Applied Statistics	4	6	6	---	2	3*	23	
		STAT- 204F	Test of Significance and Applied Statistics Lab	2							
3	V	STAT- 301F	Multivariate Analysis and Non-parametric Methods	4	10	---	---	---	---	20	UG Degree (132 Credits)
		STAT- 302F	Analysis of Variance and Design of Experiment	4							
		STAT- 303F	Non-parametric Methods and DOE Lab	2							
	VI	STAT- 304F	Statistical Computing and Introduction to Statistical Software	4	10	---	---	---	---	20	
		STAT- 305F	Operations Research	4							
		STAT- 306F	Operations Research and Statistical Computing Lab	2							
4	VII	STAT- 401F	Probability Theory	4	---	---	---	---	---	20	UG Honors (172 Credits)
		STAT- 402F	Distribution Theory	4							
		STAT- 403F	Demography	4							
		STAT- 404F	Statistical Computing	4							
		STAT- 405F	Practical (Based on theory courses)	4							
	VIII	STAT- 406F	Inference-I	4	---	---	---	---	---	20	
		STAT- 407F	Theory of Sample Survey	4							
		STAT- 408F	Multivariate Analysis	4							
		STAT- 409F	Operations Research-I	4							
		STAT- 410F	Practical (Based on theory courses)	4							

Note: **1**.SEC (Skill Enhancement Course/ Vocational Course).

2. AEC (Ability Enhancement Course/ CoCurricular Course).

3.* The student has to opt one project from subject-1/ subject-2/ subject-3.

Framework of Four Year UG Programme (UG Honors with Research)

Year	Sem.	Major1 (Subject-1) Statistics			Major 2 (Subject-2) From Same Faculty	Minor (Subject- 3) From Same/ Other Faculty	SEC/ Vocational	AEC/ CoCurricular	Disseratation/ Research Project/ Field Work/ Survey	Total	Award Degree
		Course Code	Course Title	Credits	Credits	Credits	Credits	Credits	Credits		
1	I	STAT- 101F	Descriptive Statistics (Univariate) and Theory of Probability	4	6	6	3	2	---	23	Certificate in Faculty (46 Credits)
		STAT- 102F	Descriptive Data Analysis Lab (Univariate)	2							
	II	STAT- 103F	Descriptive Statistics (Bivariate) and Probability Distributions	4	6	6	3	2	---	23	
		STAT- 104F	Descriptive Data Analysis Lab (Bivariate)	2							
2	III	STAT- 201F	Theory of Estimation and Sampling Survey	4	6	6	3	2	---	23	Diploma in Faculty (92 Credits)
		STAT- 202F	Sampling Survey Lab	2							
	IV	STAT- 203F	Testing of Hypothesis and Applied Statistics	4	6	6	---	2	3*	23	
		STAT- 204F	Test of Significance and Applied Statistics Lab	2							
3	V	STAT- 301F	Multivariate Analysis and Non-parametric Methods	4	10	---	---	---	---	20	UG Degree (132 Credits)
		STAT- 302F	Analysis of Variance and Design of Experiment	4							
		STAT- 303F	Non-parametric Methods and DOE Lab	2							
	VI	STAT- 304F	Statistical Computing and Introduction to Statistical Software	4	10	---	---	---	---	20	
		STAT- 305F	Operations Research	4							
		STAT- 306F	Operations Research and Statistical Computing Lab	2							
4	VII	STAT- 401F	Probability Theory	4	---	---	---	---	---	20	UG Honors with Research (172 Credits)
		STAT- 402F	Distribution Theory	4							
		STAT- 403F	Demography	4							
		STAT- 404F	Statistical Computing	4							
		STAT- 405F	Practical (Based on theory courses)	4							
	VIII	**Opt any two course of the following**			---	---	---	---	---	20	
		STAT- 406F	Inference-I	4 (8)							
		STAT- 407F	Theory of Sample Survey	4							
		STAT- 408F	Multivariate Analysis	4							
		STAT- 409F	Operations Research-I	4							
		Disseratation/ Research Project									
		STAT- 411F	Disseratation/ Research Project	12	----	---	---	---	12		

Note: **1**.SEC (Skill Enhancement Course/ Vocational Course).

2. AEC (Ability Enhancement Course/ CoCurricular Course).

3.* The student has to opt one project from subject-1/ subject-2/ subject-3.

Course Structure of Statistics as Major Subject in UG Honors Programme

Year	Course Code	Paper Title	Theory/Practical	Credits
FIRST		**SEMESTER-I**		
	STAT- 101F	Descriptive Statistics (Univariate) and Theory of Probability	Theory	**4+0**
	STAT- 102F	Descriptive Data Analysis Lab (Univariate)	Practical	**0+2**
		SEMESTER-II		
	STAT- 103F	Descriptive Statistics (Bivariate) and Probability Distributions	Theory	**4+0**
	STAT- 104F	Descriptive Data Analysis Lab (Bivariate)	Practical	**0+2**
SECOND		**SEMESTER-III**		
	STAT- 201F	Theory of Estimation and Sampling Survey	Theory	**4+0**
	STAT- 202F	Sampling Survey Lab	Practical	**0+2**
		SEMESTER-IV		
	STAT- 203F	Testing of Hypothesis and Applied Statistics	Theory	**4+0**
	STAT- 204F	Test of Significance and Applied Statistics Lab	Practical	**0+2**
THIRD		**SEMESTER-V**		
	STAT- 301F	Multivariate Analysis and Non-parametric Methods	Theory	**4+0**
	STAT- 302F	Analysis of Variance and Design of Experiment	Theory	**4+0**
	STAT- 303F	Non-parametric Methods and DOE Lab	Practical	**0+2**
		SEMESTER-VI		
	STAT- 304F	Statistical Computing and Introduction to Statistical Software	Theory	**4+0**
	STAT- 305F	Operations Research	Theory	**4+0**
	STAT- 306F	Operations Research and Statistical Computing Lab	Practical	**0+2**
FOURTH		**SEMESTER-VII**		
	STAT- 401F	Probability Theory	Theory	**4+0**
	STAT- 402F	Distribution Theory	Theory	**4+0**
	STAT- 403F	Demography	Theory	**4+0**
	STAT- 404F	Statistical Computing	Theory	**4+0**
	STAT- 405F	Practical (Based on theory courses)	Practical	**0+4**
		SEMESTER-VIII		
	STAT- 406F	Inference-I	Theory	**4+0**
	STAT- 407F	Theory of Sample Survey	Theory	**4+0**
	STAT- 408F	Multivariate Analysis	Theory	**4+0**
	STAT- 409F	Operations Research-I	Theory	**4+0**
	STAT- 410F	Practical (Based on theory courses)	Practical	**0+4**

Course Structure of Statistics as Major Subject in UG Honors with Research Programme

Year	Course Code	Paper Title	Theory/Practical	Credits
FIRST		**SEMESTER-I**		
	STAT- 101F	Descriptive Statistics (Univariate) and Theory of Probability	Theory	**4+0**
	STAT- 102F	Descriptive Data Analysis Lab (Univariate)	Practical	**0+2**
		SEMESTER-II		
	STAT- 103F	Descriptive Statistics (Bivariate) and Probability Distributions	Theory	**4+0**
	STAT- 104F	Descriptive Data Analysis Lab (Bivariate)	Practical	**0+2**
SECOND		**SEMESTER-III**		
	STAT- 201F	Theory of Estimation and Sampling Survey	Theory	**4+0**
	STAT- 202F	Sampling Survey Lab	Practical	**0+2**
		SEMESTER-IV		
	STAT- 203F	Testing of Hypothesis and Applied Statistics	Theory	**4+0**
	STAT- 204F	Test of Significance and Applied Statistics Lab	Practical	**0+2**
THIRD		**SEMESTER-V**		
	STAT- 301F	Multivariate Analysis and Non-parametric Methods	Theory	**4+0**
	STAT- 302F	Analysis of Variance and Design of Experiment	Theory	**4+0**
	STAT- 303F	Non-parametric Methods and DOE Lab	Practical	**0+2**
		SEMESTER-VI		
	STAT- 304F	Statistical Computing and Introduction to Statistical Software	Theory	**4+0**
	STAT- 305F	Operations Research	Theory	**4+0**
	STAT- 306F	Operations Research and Statistical Computing Lab	Practical	**0+2**
FOURTH		**SEMESTER-VII**		
	STAT- 401F	Probability Theory	Theory	**4+0**
	STAT- 402F	Distribution Theory	Theory	**4+0**
	STAT- 403F	Demography	Theory	**4+0**
	STAT- 404F	Statistical Computing	Theory	**4+0**
	STAT- 405F	Practical (Based on theory courses)	Practical	**0+4**
		SEMESTER-VIII		
	Opt any two course of the following			
	STAT- 406F	Inference-I	Theory	**4+0**
	STAT- 407F	Theory of Sample Survey	Theory	**4+0**
	STAT- 408F	Multivariate Analysis	Theory	**4+0**
	STAT- 409F	Operations Research-I	Theory	**4+0**
		Disseratation/ Research Project		
	STAT- 411F	Disseratation/ Research Project	Project	**0+12**

UG Honors:
UG Honors opt only those students who passed UG Degree.

UG Honors with Research:
UG Honors with Research opt only those students who secured 75% marks in first six semester in UG Degree.

Programme Exit Options:
The mandatory number of credits which have to be secured for the purpose of award of Certificate in Faculty/ Diploma in Faculty/UG Degree/ UG Honors/ UG Honors with Research are listed in the following table.

S. No.	Type of Award	Stage of Exit	Mandatory Credits to be Secured for the Award	Exit Options
1	Certificate in Faculty	After successful completion of Semester II	**46**	Exit option-**1**
2	Diploma in Faculty	After successful completion of Semester IV	**92**	Exit option-**2**
3	UG Degree	After successful completion of Semester VI	**132**	Exit option-**3**
4	UG Honors	After successful completion of Semester VIII	**172**	---
OR				
4	UG Honors with Research **(For students who secured 75% marks in first six semester)**	After successful completion of Semester VIII	**172**	---

Subject Prerequisites:

- To study this subject a student must had the subject(s) Mathematics in class 12^{th}.
- Mathematics subject must be compulsory in UG as a combination of Subjects for the candidates offering Statistics.

Program Outcomes (POs)

Students having Degree in UG (with Statistics) should have knowledge of different concepts and fundamentals of Statistics and ability to apply this knowledge in various fields of industry, monitoring, policy making, administration, government organisations etc. They may pursue their future career in the field of Statistics and Research.

Program Specific Outcomes (PSOs)

After completing UG (with Statistics) the student should have

PSO1. Knowledge of different concepts, principles, methodologies and tools (skills) of Statistics.

PSO2. Ability to collect, tabulate, represent graphically, analyze and interpret data/information by using appropriate statistical tools.

PSO3. Ability to identify and solve a wide range of problems in real life/industry related to Statistics.

PSO4. Familiarity with computational techniques and statistical software including programming language (e.g. R) for mathematical and statistical computation.

PSO5. Capability to use appropriate statistical skills in interdisciplinary areas such as finance, health, agriculture, government, business, industry, telecommunication and bio-statistics.

PSO6. Ability to compete with industrial/private sector demand in the field of data analysis, marketing survey, etc. in professional manner and pursue their future career in the field of Statistics.

PSO7. Ability to develop original thinking for formulating new problems and providing their solutions. As a result, they will be able to pursue higher studies or research in the field of Statistics.

FIRST YEAR (SEMESTER-I)

DESCRIPTIVE STATISTICS (UNIVARIATE) AND THEORY OF PROBABILITY

Class: UG	**Year:** FIRST	**Semester:** FIRST
Subject: STATISTICS		
Course Code: STAT- 101F	**Course Title:** Descriptive Statistics (Univariate)and Theory of Probability	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS norm.	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course, a student will have:

CO1. Knowledge of Statistics, its scope and importance in various fields.

CO2. Ability to understand concepts of sample vs. population and difference between different types of data.

CO3. Knowledge of methods for summarising data sets, including common graphical tools (such as boxplots, histograms and stemplots). Interpret histograms and boxplots.

CO4. Ability to describe data with measures of central tendency and measures of dispersion.

CO5. Ability to understand measures of skewness and kurtosis and their utility and significance.

CO6. Ability to understand the concept of probability along with basic laws and axioms of probability.

CO7. Ability to understand the terms mutually exclusive and independence and their relevance.

CO8. Ability to identify the appropriate method (i.e. union, intersection, conditional, etc.) for solving a problem.

CO9. Ability to apply basic probability principles to solve real life problems.

CO10. Ability to understand the concept of random variable (discrete and continuous), concept of probability distribution.

Course prerequisites:

To study this course, a student must have the subject Mathematics in class 12th.

Unit	Topics
	PART-A **Descriptive Statistics (Univariate)**
I	Introduction to Statistics, Meaning of Statistics, Importance of Statistics, Scope of Statistics in various fields, Concept of Statistical population, Attributes and Variables (Discrete and Continuous), Characteristics of data- Concept & Types of Measurement – Nominal, Ordinal, Ratio and Interval, systematic & random errors of measurement, accuracy & precision in statistics, Collection of data -Primary data & Secondary data – designing a questionnaire and schedule.
II	Presentation of data : Classification, Tabulation, Diagrammatic & Graphical Representation of Grouped data, Frequency distributions, Cumulative frequency distributions and their graphical representations, Histogram, Frequency polygon and Ogives. Stem and Leaf plot, Box Plot.

III	Measures of Central tendency: Arithmetic mean, Median, Mode, Geometric Mean and Harmonic Mean, their properties, Merits and Demerits of these Measures, Measures of Location: Fractiles, Quartiles, Deciles, Percentiles, Measures of Dispersion: Range, Mean Deviation, Absolute Deviation, Standard Deviation, Quartile Deviation, their properties, merits and demerits. Relative measures of dispersions: Coefficient of range, coefficient of mean deviation, coefficient of quartile deviation and coefficient of variation.
IV	Moments and Factorial moments, realtion between raw moments, central moments and moments about arbitrary point, Shephard's correction for moments, Skewness and Kurtosis,their different measures and significance.
Unit	**Topics**
PART-B **Theory of Probability**	
V	Random experiment, Trial, Sample point and Sample space, Events, Operations of events, Concept of equally likely, Mutually exclusive and Exhaustive events. Definition of Probability: Classical, Relative frequency and Axiomatic approaches.Discrete Probability Space, Properties of Probability under Set Theory Approach, Independence of Events, Conditional Probability, Total and Compound Probability theorems, Bayes theorem and its Applications.
VI	Random Variables – Discrete and Continuous, Probability Mass Function (pmf) and Probability density function (pdf), Cumulative distribution function (cdf).Joint distribution of two random variables, Marginal and Conditional distributions, Independence of random variables.
VII	Expectation of a random variable and its properties, Expectation of sum of random variables and product of independent random variables, Variance and covariance, their properties, Conditional expectation, Conditional Variance and related problems.
VIII	Moments, Moment generating function (m.g.f.) & their properties, Continuity theorem for m.g.f. (without proof). Chebyshev's inequality, Weak law of large numbers for a sequence of independently and identically distributed random variables and their applications (Statement Only), Central Limit Theorem.

Books Recommended: (Part-A Descriptive Statistics (Univariate))

1. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10th ed.), Sultan Chand and Sons.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I, World Press, Kolkata.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2011). Fundamental of Statistics, Vol II, World Press, Kolkata.
4. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
5. Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.

6. Mood, A.M. Graybill, F.A. and Boes, D.C. (2011). Introduction to the Theory of Statistics, 3rd Edn., Tata McGraw-Hill Pub. Co. Ltd.

Books Recommended: (Part-B Theory of Probability)

1. David, S. (1994) : Elementary Probability, Cambridge University Press.

2. Dudewicz, E.J. and Mishra, S.N. (2008). Modern Mathematics Statistics, Wiley.

3. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10^{th} ed.), Sultan Chand and Sons.

4. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.

5. Johnson, S. and Kotz, S. (1972). Distribution in Statistics Vol. I-II & III, Houghton and Mifflin.

6. Lipschutz, S., Lipson, M. L. and Jain, K. (2010). Schaum's Outline of Probability. 2^{nd} Edition. McGraw Hill Education Pvt. Ltd, New Delhi.

7. Meyer, P. (2017). Introductory Probability and Statistical Applications (2^{nd} ed.), New Delhi, Oxford & IBH Publishing Co. Pvt. Ltd.

8. Mood A.M., Graybill F.A. and Boes D.C. (2007). Introduction to the Theory of Statistics (3^{rd} ed.), New Delhi , Tata McGraw Hill Publishing Co. ltd.

9. Mukhopadhyay, P. (1996). Mathematical Statistics, New Delhi, New Central Book Agency Pvt. Ltd.

10. Parzen, E.S. (1992). Modern Probability Theory and its Applications. Wiley Interscience.

11. Pitman, J. (1993). Probability. Narosa Publishing House.

12. Rao, C.R. (2009). Linear Statistical Inference and its Applications, 2^{nd} Edition, Wiley Eastern.

13. Rohatgi, V.K. and Saleh, A.E. (2008). An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FIRST YEAR (SEMESTER-I)
DESCRIPTIVE DATA ANALYSIS LAB (UNIVARIATE)

Class: UG	**Year:** FIRST	**Semester:** FIRST
Subject: STATISTICS		
Course Code: STAT- 102F	**Course Title:** Descriptive Data Analysis Lab (Univariate)	
Credits: 0+2	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4		

Course outcomes:

After completing this course a student will have:

CO1. Ability to represent/summarise the data/information using appropriate Graphical methods including common graphical tools (such as boxplots, histograms and stemplots) and also to draw inferences from these graphs

CO2. Acquire the knowledge to identify the situation to apply appropriate measure of central tendency as per the nature and need of the data and draw meaningful conclusions regarding behavior of the data.

CO3. Acquire the knowledge to identify the situation to apply appropriate measure of dispersion as per the nature and need of the data and draw meaningful conclusions regarding heterogeneity of the data.

CO4. Ability to measure skewness and kurtosis of data and define their significance.

CO5. Acquire the knowledge to compute conditional probabilities based on Bayes Theorem.

Course prerequisites:

To study this course, a student must have opted/passed the paper code: STAT- 101F.

Topic

1. Problems based on graphical representation of data by Histogram, Frequency polygons, frequency curves and Ogives, Stem and Leaf Plot, Box Plot.
2. Problems based on calculation of Measures of Central Tendency.
3. Problems based on calculation of Measures of Dispersion.
4. Problems based on calculation of Moments, Measures of Skewness and Kurtosis.
5. Computation of conditional probabilities based on Bayes theorem.

Internal Evaluation Methods (Max. Marks: 25)

Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

External Evaluation Methods (Max. Marks: 75)

Practical External Evaluation shall be based on Viva-voce, Practical File/Record and Practical Exercises.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

FIRST YEAR (SEMESTER-II)

DESCRIPTIVE STATISTICS (BIVARIATE) AND PROBABILITY DISTRIBUTIONS

Class: UG	**Year:** FIRST	**Semester:** SECOND
Subject: STATISTICS		
Course Code: STAT- 103F	**Course Title:** Descriptive Statistics (Bivariate) and Probability Distributions	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course a student will have:

CO1. Knowledge of the method of least squares for curve fitting to theoretically describe experimental data with a function or equation and to find the parameters associated with the model.

CO2. Knowledge of the concepts of correlation and simple linear regression and Perform correlation and regression analysis.

CO3. Ability to interpret results from correlation and regression and their properties.

CO4. Ability to compute and interpret rank correlation. .

CO5. Ability to understand concept of qualitative data and its analysis.

CO6. Knowledge of discrete distributions. Discuss appropriate distribution negative binomial, Poisson, etc. with their properties and application of discrete distribution models to solve problems.

CO7. Knowledge of continuous distributions. Discuss the appropriate distribution (i.e. uniform, exponential, normal, etc.) with their properties and application of continuous distribution models to solve problems.

Course prerequisites:

To study this course, a student must have opted/passed the paper code: STAT- 101F.

Unit	Topics
	PART-B **Descriptive Statistics (Bivariate)**
I	Bivariate data, Principles of least squares, Most plausible values, Meaning of curve fitting, Fitting of straight line, parabola, logarithmic, power curves and other simple forms by method of least squares.
II	Bi-variate frequency table, Correlation, Types of relationships, Scatter diagram, Karl-Pearson's Correlation Coefficient and its properties.
III	Rank correlation and its coefficient (Spearman and Kendall Measures). Regression analysis through both types of regression equations for X and Y variables. Fitting of plane of regression for trivariate data, Multiple and Partial correlations.
IV	Attributes: Notion and Terminology, Contingency table, Class frequencies and Ultimate class frequencies, Consistency, Association of Attributes, Independence, Measures of association for 2X2 table, Chi-square, Karl Pearson's and Tschuprow's Coefficient of Association.
Unit	**Topics**
	PART-B **Probability Distributions**
V	Discrete Probability Distributions and their properties: Bernoulii, Binomial distribution, Poisson distribution (as limiting case of Binomial distribution), Hypergeometric, Geometric and Negative Binomial, Uniform and Multinomial distributions.

VI	Continuous Probability Distributions and their properties: Exponential, Gamma, Beta distributions, Cauchy, Laplace, Pareto, Weibull, Log normal. Transformations of variables (Univariate and Bivariate Case) distributions.
VII	Normal distribution and its properties, Standard Normal variate, Normal distribution as limiting case of Binomial and Poisson distribution, Distribution of mean of Normal Variates.
VIII	Computation of probabilities using table of Normal distribution. Bivariate Normal Distribution and its properties: Marginal and Conditional distribution and Moment Generating Function.

Books Recommended: (Part-A Descriptive Statistics (Bivariate))

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I, World Press, Kolkata.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2011). Fundamental of Statistics, Vol II, World Press, Kolkata.
3. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10^{th} ed.), Sultan Chand and Sons.
4. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
5. Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
6. Mood, A.M. Graybill, F.A. and Boes, D.C. (2011). Introduction to the Theory of Statistics, 3rd Edn., Tata McGraw-Hill Pub. Co. Ltd.
7. Weatherburn, C.E. (1961). A First Course in Mathematical Statistics, The English Lang. Book Society and Cambridge Univ. Press.

Books Recommended: (Part-B Probability Distributions)

1. David, S. (1994) : Elementary Probability, Cambridge University Press.
2. Dudewicz, E.J. and Mishra, S.N. (2008). Modern Mathematics Statistics, Wiley.
3. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10^{th} ed.), Sultan Chand and Sons.
4. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
5. Johnson, S. and Kotz, S. (1972). Distribution in Statistics Vol. I-II & III, Houghton and Mifflin.
6. Lipschutz, S., Lipson, M. L. and Jain, K. (2010). Schaum's Outline of Probability. 2^{nd} Edition. McGraw Hill Education Pvt. Ltd, New Delhi.
7. Meyer, P. (2017). Introductory Probability and Statistical Applications (2^{nd} ed.), New Delhi, Oxford & IBH Publishing Co. Pvt. Ltd.
8. Mood A.M., Graybill F.A. and Boes D.C. (2007). Introduction to the Theory of Statistics (3^{rd} ed.), New Delhi , Tata McGraw Hill Publishing Co. ltd.
9. Mukhopadhyay, P. (1996). Mathematical Statistics, New Delhi, New Central Book Agency Pvt. Ltd.
10. Parzen, E.S. (1992). Modern Probability Theory and its Applications. Wiley Interscience.
11. Pitman, J. (1993). Probability. Narosa Publishing House.
12. Rao, C.R. (2009). Linear Statistical Inference and its Applications, 2^{nd} Edition, Wiley Eastern.
13. Rohatgi, V.K. and Saleh, A.E. (2008). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FIRST YEAR (SEMESTER-II)
DESCRIPTIVE DATA ANALYSIS LAB (BIVARIATE)

Class: UG	**Year:** FIRST	**Semester:** SECOND
Subject: STATISTICS		
Course Code: STAT- 104F	**Course Title:** Descriptive Data Analysis Lab (Bivariate)	
Credits: 0+2	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4		

Course outcomes:

After completing this course a student will have:

CO1. Ability to deal with the problems based on fitting of curves by Method of least squares e.g. fitting of straight line, second degree polynomial, power curve, exponential curve etc.

CO2. Ability to deal with problems based on determination of Regression lines and calculation of Correlation coefficient – grouped and ungrouped data.

CO3. Ability to deal with the problems based on determination of Rank correlation.

CO4. Ability to fit binomial, Poisson and Normal distributions for given data.

Course prerequisites:

To study this course, a student must have opted/passed the paper code STAT- 103F.

Topic

1. Problems based on fitting of curves by Method of least squares e.g. fitting of straight line, second degree polynomial, power curve, exponential curve etc.
2. Problems based on determination of Regression lines and calculation of Correlation coefficient – grouped and ungrouped data.
3. Problems based on determination of Rank correlation.
4. Fitting of Binomial, Poisson and Normal distributions.

Internal Evaluation Methods (Max. Marks: 25)

Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

External Evaluation Methods (Max. Marks: 75)

Practical External Evaluation shall be based on Viva-voce, Practical File/Record and Practical Exercises.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

SECOND YEAR (SEMESTER-III)

THEORY OF ESTIMATION AND SAMPLING SURVEY

Class: UG	**Year:** SECOND	**Semester:** THIRD
Subject: STATISTICS		
Course Code: STAT- 201F	**Course Title:** Theory of Estimation and Sampling Survey	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course a student will have:

CO1. Knowledge of the concept of Sampling distributions.
CO2. Ability to understand the difference between parameter & statistic and standard error & standard deviation.
CO3. Knowledge of the sampling distribution of the sum and mean.
CO4. Ability to understand the t, F and chi-square distribution and to identify the main characteristics of these distributions.
CO5. Knowledge of the concept of Point and Interval Estimation and discuss characteristics of a good estimator.
CO6. Ability to understand and practice various methods of estimations of parameters.
CO7. Ability to understand the concept of sampling and how it is different from complete enumeration.
CO8. Knowledge of various probability and non-probability sampling methods along with estimates of population parameters
CO9. Ability to identify the situations where the various sampling techniques shall be used.
CO10. Knowledge of sampling and non-sampling errors.
CO11. Knowledge of ratio methods of estimation in simple random sampling (SRS).

Course prerequisites:

To study this course, a student must have opted/passed the paper code: STAT- 103F.

Unit	Topics
	PART-A **Sampling Distributions and Theory of Estimation**
I	Sampling Distributions: The concept of sampling distribution, Parameter, Statistic and Standard error, sampling distribution of Chi-Square, t, F and Z, properties of these distributions and their inter-relationships.
II	Point estimation: Characteristics of a good estimator: Unbiasedness, consistency, sufficiency and efficiency. Related Problems and examples
III	Method of Maximum Likelihood and properties of maximum likelihood estimators (without proof), Method of minimum Chi-square. Method of least squares and methods of moments for estimation of parameters, Cramer-Rao inequality and its use in finding MVU estimator.
IV	Interval Estimation,Confidence Interval and Confidence limits,Concept of best confidence intervals,Confidence Intervals for large samples with examples.
Unit	**Topics**
	PART-B **Sampling Survey**
V	Sampling vs. Complete enumeration: Sampling units and Sampling frame, Precision and efficiency of estimators, Simple Random sampling with and without replacement, Use of random number tables in selection of simple random sample, Estimation of population mean and proportion, Derivation of expression for variance of these estimators, Estimation of variances, Sample size determination.
VI	Stratified random sampling, Problem of allocation, proportional allocation, optimum allocation. Derivation of the expressions for the standard error of the usual estimators when these allocations are used, Gain in precision due to Stratification, Role of sampling cost in the sample allocation, Minimization of variance for fixed cost.

VII	Systematic Sampling: Estimation of Population mean and Population total, standard errors of these estimators, Ratio methods of estimation in simple random sampling.
VIII	Cluster sampling with equal clusters, Estimators of population mean and their mean square errors, Two stage sampling with equal first stage units: Estimation of Population mean and its variance. Non-sampling errors.

Books Recommended: (Part-A Sampling Distributions and Theory of Estimation)

1. Ferund J.E (2001) : Mathematical Statistics, Prentice Hall of India.
2. Freedman, D., Pisani, R. and Purves, R. (2014). Statistics. 4th Edition. Norton & Comp.
3. Goon, A.M., Gupta, M.K. &Dasgupta, B. (2002). Fundamentals of Statistics, Vol. I. ,Kolkata, The World Press.
4. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10th ed.), Sultan Chand and Sons.
5. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
6. Hogg, R.V., McKean, J.W. & Craig, A.T. (2009). Introduction to Mathematical Statistics (6th ed.), Pearson.
7. Kendall, M.G. and Stuart, A. (1979). The Advanced Theory of Statistics, Vol.2. Inference and Relationship. 4th Edition. Charles Griffin & Comp.
8. Kendall, M.G., Stuart, A. and Ord, J.K. (1994). The Advanced Theory of Statistics, Vol. 1. Distribution Theory. 6th Edition. Halsted Press (Wiley Inc.).
9. Kenney, J.F. and Keeping, E.S. (1947). Mathematics of Statistics. Part I. 2nd Edition. Chapman & Hall.
10. Kenney, J.F. and Keeping, E.S. (1951). Mathematics of Statistics. Part II. 2nd Edition. Chapman & Hall.
11. Mood A.M., Graybill F.A. and Boes D.C. (2007). Introduction to the Theory of Statistics (3rd ed.), New Delhi , Tata McGraw Hill Publishing Co. ltd.
12. Tanner, M. (1990). An Investigation for a Course in Statistics. McMillan, New York.
13. Tanur, J.M. (1989) Statistics. A Guide to the Unknown. 3rd Edition, Duxbury Press.
14. Yule, G.U. and Kendall, M.G. (1973). An Introduction to the Theory of Statistics.14th Edition. Charles Griffin & Comp.

Books Recommended: (Part-B Sampling Survey)

1. Ardilly, P. and Yves T. (2006). Sampling Methods: Exercise and Solutions. Springer.
2. Cochran, W.G. (2007). Sampling Techniques. (Third Edition). John Wiley & Sons, New Delhi.
3. Cochran, W.G. (2008). Sampling Techniques (3rd ed.), Wiley India.
4. Des Raj. (1976). Sampling Theory. Tata McGraw Hill, New York. (Reprint 1979).
5. DesRaj and Chandhok, P. (1998). Sample Survey Theory, Narosa Publishing House.
6. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10th ed.), Sultan Chand and Sons.
7. Mukhopadyay, P. (2007). Survey Sampling. Narosa Publisher, New Delhi.
8. Murthy, M. N. (1977). Sampling Theory and Statistical Methods. Statistical Pub. Society, Kolkata.
9. Singh, D. and Choudhary, F.S. (1977). Theory and Analysis of Sample Survey Designs. Wiley Eastern Ltd, New Delhi. (Reprint 1986)
10. Sukhatme, P.V. and Sukhatme, B.V. (1970). Sampling Theory Surveys with Applications (Second Edition). Iowa State University Press.
11. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. &Asok, C. (1984): Sampling Theories of Survey with Applications, IOWA State University Press and ISAS.
12. Thompson, S.K. (2012). Sampling. John Wiley & Sons.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

SECOND YEAR (SEMESTER-III)
SAMPLING TECHNIQUES LAB

Class: UG	**Year:** SECOND	**Semester:** THIRD
Subject: STATISTICS		
Course Code: STAT- 202F	**Course Title:** Sampling Techniques Lab	
Credits: 0+2	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4

Course outcomes:

After completing this course a student will have:

CO1. Ability to draw a simple random sample with the help of table of random numbers.

CO2. Ability to estimate population means and variance in simple random sampling.

CO3. Ability to deal with problems based on Stratified random sampling for population means (proportional and optimum allocation).

CO4. Ability to deal with problems based on Systematic random sampling

CO5. Ability to deal with problems based on two stage sampling

CO6. Ability to deal with problems based on Ratio estimation of population mean and total.

Course prerequisites:

To study this course, a student must have opted/passed the paper code STAT- 201F.

Topic

1. Problems based on drawing a simple random sample with the help of table of random numbers.
2. Problems based on estimation of population means and variance in simple random sampling.
3. Problems based on Stratified random sampling for population means (proportional and optimum allocation).
4. Problems based on Systematic random sampling
5. Problems based on two stage sampling
6. Problems based on Ratio estimation of population mean and total.

Internal Evaluation Methods (Max. Marks: 25)

Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

External Evaluation Methods (Max. Marks: 75)

Practical External Evaluation shall be based on Viva-voce, Practical Exercises and Overall performance.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

SECOND YEAR (SEMESTER-IV)

TESTING OF HYPOTHESIS AND APPLIED STATISTICS

Class: UG	**Year:** SECOND	**Semester:** FOURTH
Subject: STATISTICS		
Course Code: STAT- 203F	**Course Title:** Testing of Hypothesis and Applied Statistics	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course a student will have:

CO1. Knowledge of the terms like null and alternative hypotheses, two-tailed and one-tailed alternative hypotheses, significant and insignificant, level of significance and confidence, p value etc.

CO2. Ability to understand the concept of MP and UMP tests.

CO3. Ability to understand under what situations one would conduct the small sample and large sample tests (in case of one sample and two sample tests).

CO4. Familiarity with different aspects of Applied Statistics and their use in real life situations.

CO5. Ability to understand the concept of Time series along with its different components.

CO6. Knowledge of Index numbers and their applications along with different types of Index numbers.

CO7. Familiarity with various demographic methods and different measures of mortality and fertility.

CO8. Ability to understand the concept of life table and its construction.

CO9. Knowledge to understand the concept of statistical quality control and different control charts for variables and attributes.

Course prerequisites:

To study this course, a student must have opted/passed the paper code: STAT- 201F.

Unit	Topics
	PART-A **Testing of Hypothesis and Tests of Significance**
I	Statistical Hypothesis (Simple and Composite), Testing of hypothesis. Type –I and Type – II errors, Significance level, p-values,Power of a test,Most Powerful(MP) test,Uniformly Most Powerful (UMP)Test,Uniformly Most Powerful Unbiased (UMPU)Test
II	Neyman Pearson Lemma(Statement and proof) and its use in finding BCR and UMPCR,Likelihood Ratio test and its reductions to standard test.
III	Test of significance: Large sample tests for (Attributes and Variables) proportions and meansand variances (i) for one sample (ii) for two samples. Correlation coefficient in case of (a) $p=p_0$ (b) $p_1=p_2$,
IV	Small sample tests based on chi-square,t, F and Zdistributions.
Unit	**Topics**
	PART-B **Sampling Survey**
V	Introduction & Definition of Time Series, its different components, illustrations, additive and multiplicative models. Determination of trend by free hand curve, semi average method, moving average method, method of least squares, Analysis of Seasonal Component by Simple average method, Ratio to moving Average Ratio to Trend, Link relative method.
VI	Index number – its definition, application of index number, price relative and quantity or volume relatives, link and chain relative, problem involved in computation of index number, use of averages, simple aggregate and weighted average method. Laspeyre's, Paasche's, Fisher's and Marshall-Edgeworth index number, Criteria of an ideal index number: unit, time reversal, factor reversal and circular tests, consumer price index.

VII	Vital Statistics: Measurement of Fertility– Crude birth rate, general fertility rate, age-specific birth rate, total fertility rate, gross reproduction rate, net reproduction rate, Death rates: Crude death rate, Age specific death rate, standardized death rates. Complete life table, its main features and construction.
VIII	Introduction to Statistical Quality Control, Process control and Product control, tools of statistical quality control, 3σ control limits, Principle underlying the construction of control charts. Control charts for variables, '$\bar{X}$', 'R' and 'σ' charts, their construction and interpretation, Control charts for attributes: charts for number of defects per unit (c-chart), fraction defectives and number of defectives, their construction and interpretation. Sampling inspection for attributes – Single and Double Sampling plans: OC function, ASN, ATI, LTPD, Producer's risk, Consumer's risk

Books Recommended: (Part- Testing of Hypothesis and Tests of Significance)

1. Ferund J.E (2001) : Mathematical Statistics, Prentice Hall of India.
2. Freedman, D., Pisani, R. and Purves, R. (2014). Statistics. 4th Edition. Norton & Comp.
3. Goon, A.M., Gupta, M.K. &Dasgupta, B. (2002). Fundamentals of Statistics, Vol. I. ,Kolkata, The World Press.
4. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10th ed.), Sultan Chand and Sons.
5. Hangal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
6. Hogg, R.V., McKean, J.W. & Craig, A.T. (2009). Introduction to Mathematical Statistics (6th ed.), Pearson.
7. Kendall, M.G. and Stuart, A. (1979). The Advanced Theory of Statistics, Vol.2. Inference and Relationship. 4th Edition. Charles Griffin & Comp.
8. Kendall, M.G., Stuart, A. and Ord, J.K. (1994). The Advanced Theory of Statistics, Vol. 1. Distribution Theory. 6th Edition. Halsted Press (Wiley Inc.).
9. Kenney, J.F. and Keeping, E.S. (1947). Mathematics of Statistics. Part I. 2nd Edition. Chapman & Hall.
10. Kenney, J.F. and Keeping, E.S. (1951). Mathematics of Statistics. Part II. 2nd Edition. Chapman & Hall.
11. Mood A.M., Graybill F.A. and Boes D.C. (2007). Introduction to the Theory of Statistics (3rd ed.), New Delhi , Tata McGraw Hill Publishing Co. ltd.
12. Tanner, M. (1990). An Investigation for a Course in Statistics. McMillan, New York.
13. Tanur, J.M. (1989) Statistics. A Guide to the Unknown. 3rd Edition, Duxbury Press.
14. Yule, G.U. and Kendall, M.G. (1973). An Introduction to the Theory of Statistics.14th Edition. Charles Griffin & Comp.

Books Recommended: (Part-B Sampling Survey)

1. Croxton F.E., Cowden D.J. and Klein, S. (1973). Applied General Statistics(3rd ed.), Prentice Hall of India Pvt. Ltd.
2. Gupta, S.C. and Kapoor, V.K. (2008). Fundamentals of Applied Statistics (4th ed.), Sultan Chand and Sons.
3. Montgomery D.C. (2009) : Introduction to Statistical Quality Control (6th ed.), Wiley India Pvt. Ltd.
4. Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied (P) Ltd.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

SECOND YEAR (SEMESTER-IV)
TESTS OF SIGNIFICANCE AND APPLIED STATISTICS LAB

Class: UG	**Year:** SECOND	**Semester:** FOURTH
Subject: STATISTICS		
Course Code: STAT- 204F	**Course Title:** Tests of Significance and Applied Statistics Lab	
Credits: 0+2	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4

Course outcomes:

After completing this course a student will have:

CO1. Ability to conduct test of significance based on t – test and Chi-square test.
CO2. Knowledge about Fisher's Z-transformation and its use in testing
CO3. Ability to deal with problems based on large sample tests.
CO4. Ability to deal with problems based on time series and calculation of its different components for forecasting.
CO5. Ability to deal with problems based on Index number.
CO6. Acquire knowledge about measurement of mortality and fertility.
CO7. Ability to deal with problems based on life table.
CO8. Ability to work with control charts for variables and attributes and draw inferences.

Course prerequisites:

To study this course, a student must have opted/passed the paper code STAT- 203F.

Topic

1. Problems based on t – test.
2. Problems based on F-test.
3. Problems based on Chi-square test.
4. Problems based on Fisher's Z-transformation and its use in testing
5. Problems based on calculation of power curve.
6. Problems based on large sample tests.
7. Problems based on time series and its different components
8. Problems based on Index number.
9. Problems based on measurement of mortality and fertility.
10. Problems based on life table.
11. Problems based on control charts for variables and attributes.

Internal Evaluation Methods (Max. Marks: 25)

Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

External Evaluation Methods (Max. Marks: 75)

Practical External Evaluation shall be based on Viva-voce, Practical Exercises and Overall performance.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

SECOND YEAR (SEMESTER-IV)
PROJECT

Class: UG	**Year:** SECOND	**Semester:** FOURTH
Subject: STATISTICS		
Course Code: As prescribed by the University	**Course Title:** PROJECT	
Credits:0+3	**The student can opt any one as a project from subject-1,2,3 (Major-I, Major-2, Minor-3) in semester-IV**	
Max. Marks: 100	**Min. Passing Marks:** As per University CBCS Norm	

Course Outcomes:

CO 1. The objective of course is to write a project on the specific topic.

CO 2. The student shall be able to do their research work in different interdisciplinary areas.

CO 3. After completing the course, the student shall be able to understand some advanced statistical techniques.

Course prerequisites:

To study this course, a student must have passed Statistics as Major Subject in UG Semester-I, II and III Programme.

PROJECT

Candidate/Students should write a project on the specific topic based on any one core/major papers opted by the student in semester- I, II, III and IV. The students has been allotted a supervisor in this research project on their topic, given by the concern faculty. The project should be typed.

Evaluation Methods (Max. Marks: 100)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-V)

MULTIVARIATE ANALYSIS AND NON-PARAMETRIC METHODS

Class: UG	**Year:** THIRD	**Semester:** FIFTY
Subject: STATISTICS		
Course Code: STAT- 301F	**Course Title:** Multivariate Analysis and Non-parametric Methods	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course a student will have:

CO1. Ability to understand the basic concepts of vector space and matrices in order to study multivariate distribution.

CO2. Knowledge of the applications of multivariate normal distribution and Maximum Likelihood estimates of mean vector and dispersion matrix.

CO3. Knowledge of Principal Component Analysis and Factor Analysis.

CO4. Knowledge of the formal definition of order statistics, derive the distribution function and probability density function of the r^{th} order statistic and joint distribution of r^{th} and s^{th} order statistics.

CO5. Ability to identify the application of theory of order statistics in real life problems.

CO6. Ability to apply distribution free tests (Non-parametric methods) for one and two sample cases.

Course prerequisites:
To study this course, a student must have opted/passed the paper code: STAT- 201F and STAT- 203F.

Unit	Topics
I	Order Statistics,Distribution of minimum,rth and maximum order statistic,joint distribution of rth and sth order statistics in continuous case, distribution of Sample Median and Range and their examples related to for Uniform and Exponential distribution,Coverages and Tolrence limits, Quantiles.
II	Multivariate Normal Distribution and its properties, Marginal and Conditional Distributions, Moment Generating and Characteristics functions.
III	Sample from multivariate normal distribution, unbised estimators of Mean vector and Dispersion matrix, Maximum Likelihood Estimation of Mean vector and Dispersion matrix, Independence and point sufficiency of these estimates.
IV	Simple Linear Regression: Model and Assumptions, Least squares theory. Estimation of parameters-OLSE and MLE of parameters and its properties, estimation of error variance, test of hypotheses for parameters.
V	Multiple Linear Regression: Estimation of parameters in k variable linear Regression model (OLSE and MLE), ANOVA-Table, Tests Of Hypothesis, R square and Adjusted R square. Coefficient of determination.
VI	Non-parametric tests, Comparison with parametric tests, Tests for randomness and Kolmogorov–Smirnov's test for goodness of fit. One sample tests : Sign test, Wilcoxon Signed rank tests.

VII	Two sample tests: Wald-Wolfowitz Run test, Kolmogorov – Smirnov's test. Paired sample tests: Sign test, Wilcoxon signed rank test. Independent sample tests: Wilcoxon Rank sum test, Median test and Mann-Whitney U test.
VIII	Test for scale parameter: Mood's Test, Shukahtme Test. Kurskall Wallis test. Spearman's rank correlation test.

Books Recommended:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972): Multivariate Analysis, 1stEdn. Marcel Dekker.
4. Johnson, R.A. And Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn., Pearson & Prentice Hall
5. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press,Kolkata.
6. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC.
7. Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics.2ndEdn. (Reprint) John Wileyand Sons.
8. David, H.A. (1981). Order Statistics (2nd ed.), New York, John Wiley.
9. Montgomery, D.C., Peck, E.A.and Vining, G.G.(2012).Introduction to Linear Regression Analysis, 5th Edition, Wiley.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-V)

ANALYSIS OF VARIANCE AND DESIGN OF EXPERIMENT

Class: UG	**Year:** THIRD	**Semester:** FIFTY
Subject: STATISTICS		
Course Code: STAT- 302F	**Course Title:** Analysis of Variance and Design of Experiment	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course a student will have:

CO1. Knowledge of the concept of Analysis of Variance (ANOVA).
CO2. Ability to carry out the ANOVA for One way and Two way Classification.
CO3. Ability to carry out the post-hoc analysis.
CO4. Knowledge of the concept of Design of experiment and its basic principles.
CO5. Ability to perform the basic symmetric designs CRD, RBD and LSD with and without missing observations.
CO6. Knowledge of the concept of factorial experiments and their practical applications.

Course prerequisites:

To study this course, a student must have opted/passed the Mathematics in Class 12^{th}.

Unit	Topics
I	Definition of Analysis of Variance, Assumptions and Limitations of ANOVA, One way classification. Two way classification with one observation per cell.
II	Two way classification with equal number of observations per cell, Duncan's test for multiple comparison. Analysis of covariance (One way classification only).
III	Principles of Design of Experiment: Randomization, Replication and Local Control, Choice of size and type of a plot using uniformity trials. Completely Randomised Design (CRD)
IV	Randomized Block Design (RBD), Concept and definition of efficiency of design, Comparison of efficiency between CRD and RBD.
V	Latin Square Design (LSD), Lay-out, ANOVA table, Comparison of efficiencies between LSD and RBD; LSD and CRD
VI	Missing plot technique: Estimation of missing plots by minimizing error sum of squares in RBD and LSD with one or two missing observations.
VII	Factorial Experiments: General description of factorial experiments, 2^2, 2^3 and 2^n factorial experiments arranged in RBD, Definition of Main effects and Interactions in 2^2 and 2^3 factorial experiments. Estimation of main and interaction effect, Yates procedure, ANOVA-Table.
VIII	Concept of confounding: Complete and Partial, confounding in 2-level factorial experiments. Introduction to 3-level factorial experiments.

Books Recommended:

1. Cochran, W. G. and Cox, G. M. (1957). Experimental Design. John Wiley & Sons, New York.
2. Cochran, W.G. and Cox, G.M. (2003). Experimental Design, Asia Publishing House
3. Das, M. N. and Giri, N. S. (1986). Design and Analysis of Experiments (2^{nd} Edition). Wiley.
4. Joshi, D.D. (1987). Linear Estimation and Design of Experiments. New Age International (P) Ltd. New Delhi.
5. Kempthorne, O. (1965). The Design and Analysis of Experiments, John Wiley
6. Montgomery, D.C. (2017). Design and analysis of Experiments, 9^{Th} Edition. John Wiley &Sons..

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-V)
NON-PARAMETRIC METHODS AND DOE LAB

Class: UG	**Year:** THIRD	**Semester:** FIFTY
Subject: STATISTICS		
Course Code: STAT- 303F	**Course Title:** Non-parametric Methods and DOE Lab	
Credits: 0+2	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4		

Course outcomes:

After completing this course a student will have:

CO1. Ability to conduct test of significance based non-parametric tests.

CO2. Ability to deal with multivariate data.

CO3. Knowledge of Principal Component Analysis and Factor Analysis. Ability to perform ANOVA for one way and two classification.

CO4. Ability to perform post-hoc analysis.

CO5. Ability to conduct analysis of CRD, RBD and LSD with and without missing observations.

CO6. Ability to conduct analysis for Factorial experiments (without confounding).

Course prerequisites:

To study this course, a student must have opted/passed the paper code STAT- 301F and STAT- 302F.

Topic

1. Problems based on Non-parametric tests for one sample.
2. Problems based on Non-parametric tests for two samples.
3. Problems based on Mean vector, Dispersion matrix, marginal and conditional distribution of a multivariate normal distribution.
4. Problems based on Analysis of variance in one-way and two-way classification (with and without interaction terms).
5. Problems based on Analysis of a CRD, RBD LSD.
6. Problems based on Analysis of variance in RBD and LSD with one or two missing observations.
7. Problems based on 2^2 and 2^3 Factorial Experiment.

Internal Evaluation Methods (Max. Marks: 25)

Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

External Evaluation Methods (Max. Marks: 75)

Practical External Evaluation shall be based on Viva-voce, Practical Exercises and Overall performance.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

THIRD YEAR (SEMESTER-VI)

STATISTICAL COMPUTING AND INTRODUCTION TO STATISTICAL SOFTWARE

Class: UG	**Year:** THIRD	**Semester:** SIXTH
Subject: STATISTICS		
Course Code: STAT- 304F	**Course Title:** Statistical Computing and Introduction to Statistical Software	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course a student will have:

CO1. Basic Knowledge of programming with some basic notions for developing their own simple programs and visualizing graphics in R.

CO2. Ability to perform data analysis for both univariate and multivariate data sets using R.

CO3. Ability to perform to perform numerical methods.

Course prerequisites:

To study this course, a student must have had the subject Mathematics in class 12^{th}.

Unit	Topics
I	Introduction to Computer: Generation of Computer, Basic Structure of Computer, Digital computer and its peripherals, number systems (Binary, Octal, Hexadecimal Systems). Flow chart for simple statistical problems.
II	Introduction to R Programming and R Studio, Installing R, R as a calculator. Creating a data set, Understanding a data set, Data structure: Vectors, Matrices, Arrays, Data Frames, Factors andLists. Simple matrix algebra in R
III	Data inputs: Entering data from the keyboard, Importing Data in R from external source, creating new variables, recoding variable, renaming variables, sorting data, merging and sub setting dataset, Missing values, Descriptive Statistics.
IV	Graphs using R, Inferential Statistics- Parametric test: Test for Normality, t-test for single mean, t-test for difference between means, paired t-test, Test for equality of two variances.
V	Using R/SPSS: Wilcoxon signed rank test, Wilcoxon rank sum test, Mann-Whitney U test, Kruskal Wallis test, Analysis of Variance (One-way &Two wayAnova), Correlation coefficients and their tests, Linear Regression: Simple and Multiple regression.
VI	Error in numerical computations, Calculus of finite differences, Difference operators, Interpolation with equal and unequal intervals, Newton's forward and backward interpolation formulae, Lagrange's interpolation formula.
VII	Solutions of algebraic and transcendental equations, Direct and iterative methods, Bisection method, Regula-falsi method, Newton- Raphson method, Iteration method
VIII	Numerical Integration, General Quadrature formula, Trapezoidal rule, Simpson's one-third and tree-eight formulae and Weddle's rules.

Books Recommended:

1. Chambers, J. (2008). Software for Data Analysis: Programming with R, Springer.
2. Crawley, M.J. (2017). The R Book, John Wiley & Sons.
3. Eckhouse, R.H. and Morris, L.R. (1975). Minicomputer Systems Organization, Programming and Applications, Prentice-Hall.
4. Matloff, N. (2011). The Art of R Programming, No Starch Press, Inc.
5. Eckhouse, R.H. and Morris, L.R. (1975). Minicomputer Systems Organization, Programming and Applications, Prentice-Hall.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-VI)

OPERATIONS RESEARCH

Class: UG	**Year:** THIRD	**Semester:** SIXTH
Subject: STATISTICS		
Course Code: STAT- 305F	**Course Title:** Operations Research	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course a student will have:

CO1. An idea about the historical background and need of Operations research.

CO2. Ability to identify and develop operational research models from the verbal description of the real life problems.

CO3. Knowledge of the mathematical tools that are needed to solve optimization problems.

CO4. Ability of solving Linear programming problem, Transportation and Assignment problems, travelling salesman problem, Job sequencing, etc.

CO5. Ability to solve the problems based on Game Theory.

Course prerequisites:

To study this course, a student must have opted/passed the Mathematics in Class 12^{th}.

Unit	Topics
I	History & background of OR, Developing mathematical models, Mathematical programming, Linear programming, Convex sets, Convex and concave functions, Theorems on convexity, General linear programming problems and their formulations. Solving LPP by Graphical Method.
II	Solving LPP by, Simplex method, Big–M method, Two phase Method, Degeneracy and Duality in LPP.
III	Transportation problem: North-west corner rule, Least cost method, Vogel's approximation method. Optimum solution: Stepping stone method.
IV	Assignment Problem: Hungarian Method, balanced and unbalanced problem, maximization problems, Travelling Salesman Problem.
V	Inventory control, different costs involved in inventory control, factors affecting inventory control, Deterministic EOQ models without and with shortages.
VI	Job sequencing: n jobs – 2 machines, n jobs – k machines, 2 jobs – n machines.
VII	Game Theory: Competitive game, Two-Person Zero-Sum (Rectangular) game, Minimax-maximin criteria, Saddle points, Solution of rectangular game with and without saddle points.
VIII	Huge rectangular games, Dominance rules, Solution of huge rectangular games using rules of dominance, Graphical method for 2xn and mx2 games without saddle points

Books Recommended:

1. Swarup, K., Gupta P.K. and ManMohan (2007). Operations Research (13th ed.), Sultan Chand & Sons.
2. Taha, H.A. (2007). Operations Research: An Introduction(8th ed.), Prentice Hall of India.
3. Hadley, G: (2002) : Linear Programming, Narosa Publications
4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research- Concepts and cases, 9th Edition, Tata McGraw Hill
5. V. S. Verma, Linear Programming and Game Theory, NeelkamalPrakashan, Gorakhpur, 2011.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-VI)
OPERATIONS RESEARCH AND STATISTICAL COMPUTING LAB

Class: UG	**Year:** THIRD	**Semester:** SIXTH
Subject: STATISTICS		
Course Code: STAT- 306F	**Course Title:** Operations Research and Statistical Computing Lab	
Credits: 0+2	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4

Course outcomes:
After completing this course a student will have:
CO1. Knowledge of mathematical formulation of L.P.P
CO2. Ability of solving LPP using different methods.
CO3. Ability to solve Allocation Problem based on Transportation and .Assignment model.
CO4. Ability to solve problems based on Game Theory.
CO5. Ability to deal with the scaling procedures.
CO6. Ability to deal with tests based on reliability and valididty.
CO7. Ability to solve finite difference and numerical integration.

Course prerequisites:
To study this course, a student must have opted/passed the paper code: STAT- 304F and STAT-305F.

Topic

1. Problem based on Mathematical formulation of L.P.P.
2. Problem based on solving LPP using Graphical Method.
3. Problem based on solving LPP using Simplex Method
4. Problem based on solving LPP using Big-M and Two-phase method involving artificial variables.
5. Problems based on Transportation Problems.
6. Problem based on Assignment method.
7. Problem based on solving game using LPP method.
8. Problem based on job sequencing.
9. Problems based on 2xn and mx2 games.
10. Problem based on application of R as calculator.
11. Problem based on application of R.
12. Problem based on application of R for matrix algebra.

Internal Evaluation Methods (Max. Marks: 25)
Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

External Evaluation Methods (Max. Marks: 75)
Practical External Evaluation shall be based on Viva-voce, Practical Exercises and Overall performance.
{As prescribed by the University (as per common ordinance for examination and assessment)}.

FOURTH YEAR (SEMESTER-VII)

PROBABILITY THEORY

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: STATISTICS		
Course Code: STAT- 401F	**Course Title:** Probability Theory	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course, a student will be able to:

CO 1. Understand the concepts of random variables, sigma-fields generated by random variables.

CO 2. Learn probability distributions and independence of random variables related to measurable functions.

CO 3. Gain the ability to understand the concepts of different types of generating function, sequence of random variables, convergence, modes of convergence of sequence of random variables.

CO 4. Learn the concepts of weak and strong laws of large numbers, and central limit theorem.

Course prerequisites:

To study this course, a student must have passed Statistics as Major Subject in UG Third Year Programme.

Unit	Topics
I	Classes of sets, field, sigma field, minimal sigma field, Borel field, sequence of sets, limits of a sequence of sets, measure, probability measure, Integration with respect to measure. Random experiment, outcomes, sample space, events, various definitions of probability, laws of total and compound probability. Boole's inequality. Conditional probability, independence of events. Bayes Theorem.
II	Random variable, probability mass function, probability density function, cumulative distribution function. Expectation of a random variable, properties of expectation. Bivariate distributions and the joint probability distribution. Independence of random variables. Marginal and conditional distributions. Conditional expectation and its properties.
III	Moment generating function, probability generating function, cumulant generating function, characteristic function and their properties. Inversion, continuity and uniqueness theorems.
IV	Convergence in probability, almost sure convergence, convergence in distribution and their relationships. Chebyshev's inequality, weak law of large numbers (WLLN), strong law of large numbers (SLLN), central limit theorems.

Books Recommended:

Rohatgi V.K. & Saleh A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.

Rao, B.L.S.P. (2010): A First Course in Probability and Statistics. World Scientific.

Hogg, R.V., McKean, J. & Craig, A.T. (2013). Introduction to Mathematical Statistics, 7th Ed. Pearson.

Mukhopadhyay, P. (2015). Mathematical Statistics. New Central Book Agency.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VII)

Distribution Theory

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: STATISTICS		
Course Code: STAT- 402F	**Course Title:** Distribution Theory	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course, a student will be able to:

CO 1. Understand the concepts of random variables, sigma-fields generated by random variables.

CO 2. Learn probability distributions and independence of random variables related to measurable functions.

CO 3. Gain the ability to understand the concepts of different types of generating function, sequence of random variables, convergence, modes of convergence of sequence of random variables.

CO 4.Learn the concepts of weak and strong laws of large numbers, and central limit theorem.

Course prerequisites:

To study this course, a student must have passed Statistics as Major Subject in UG Third Year Programme.

Unit	Topics
I	Brief review of basic distribution theory. Joint, marginal and conditional p.m.fs. and p.d.fs Discrete Probability Distributions and their properties: Bernoulli, Binomial, Poisson distribution, Hypergeometric, Geometric and Negative Binomial, and Multinomial distributions.
II	Continuous probability distributions and their properties: Exponential, Gamma, Beta, Cauchy, Laplace, Pareto, Weibull, Normal and Log normal distributions.
III	Central and Non-central Chi-square, t and F distributions with their properties Bivariate Normal Distribution and its properties: Marginal and conditional distributions and moment generating function.
IV	Functions of random variables and their distributions using Jacobian of Transformation and other tools. Compound, truncated and mixture distributions. Conditional expectation. Order statistics –their distributions and properties.

Books Recommended:

1. Krishnamoorthy, K. (2015). Handbook of Statistical Distributions with Applications, 2nd Ed. CRC Press.
2. Rohatgi V.K. & Saleh A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.
3. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I. World Press.
4. Forbes, C., Evans, M., Hastings, N. & Peacock, B. (2010). Statistical Distributions, 4th Edition. Wiley.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VII)

DEMOGRAPHY

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: STATISTICS		
Course Code: STAT- 403F	**Course Title:** Demography	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course, a student will be able to:

CO 1. Identify principal course of demographic data and their strengths and weaknesses.

CO 2.Discuss the demographic significance of age sex structure and their implications on society

CO 3.Develop analytical abilities of different demographic concept in quantitative term.

CO 4.In position to identify the components of population change and their effect and influence in human society

Course prerequisites:

To study this course, a student must have passed Statistics as Major Subject in UG Third Year Programme.

Unit	Topics
I	Source of demographic data. Scope and application of demography. Population composition and its measures. Dependence ratio, Basic Demographic equation.
II	Measures of fertility: Crude birth rate, general fertility rate, age-specific birth rate, total fertility rate (TFR). Measurement of population growth: Gross reproduction rate (GRR) and net reproduction rate (NRR).
III	Measures of mortality: Crude, standardized and age-specific death rate, infant mortality rates. Complete life table and its main features, Construction of Abridged life table by Grevilles method, Reed and Marrel method. Uses of life table.
IV	Theory of migration, types and measures of migration, migration rates. Volume of migration and its estimation. Nuptiality analysis and Population projection .

Books Recommended:

1. Keyfitz, N. (1977) Applied Mathematical Demography John Wiley & Sons N.Y.
2. Cox P.R. (1976): Demography, Cambridge University Press.
3. Spiegelman, M. (1980) Introduction to Demography Harvard University Press
4. R. Ramakumar (1986): Technical Demography, Wiley Eastern limited

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VII)
STATISTICAL COMPUTING

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: STATISTICS		
Course Code: STAT- 404F	**Course Title:** Statistical Computing	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course, a student will be able to:

CO 1. understand linear algebra and matrix algebra.

CO 2.apply the modern data analysis techniques

CO 3.computation of various quantities associated with probability distributions.

CO 4.use R programming with some basic notions for developing their own simple programs and visualizing graphics in R.

CO 5.perform Computation using R programming.

Course prerequisites:

To study this course, a student must have passed Statistics as Major Subject in UG Third Year Programme.

Unit	Topics
I	Introduction to Data Science and statistical computing. Elements of modern data analysis techniques: Tools for data analysis (numerical and visual summaries): descriptive statistics with graphics, Bivarite data : correlation and regression analysis, representation of multivariate data and its visualization.
II	Exploratory data analysis: Empirical Distribution Function and its properties, quantile function. Introduction to object-oriented programming, simple syntax, loops, functions, arrays, input/output, workspace and files, scripts and packages. Linear Algebra : Solutions of matrix equations, generalized inverse, Idempotent matrices, Real quadratic forms, index and signature, triangular reduction of a positive definite matrix. Eigen values and vectors, algebraic and geometric multiplicity of eigen values, vector and matrix differentiation.
III	Numerical integration of one variable function. Solution of non-linear equations: Roots extraction using different methods, Newton-Raphson and other iterative procedures. Numerical optimization, Matrix computation: addition, subtraction, transpose, multiplication, inverse, eigen values, eigen vectors and Spectral decomposition of a real symmetric matrix. singular value decomposition, Solution of system of linear equations
IV	Probability distributions: Computation of pdf, cdf, percentiles(tail areas) and relevant measures of location and dispersion of various univariate continuous probability distributions and associated graphics. Stochastic simulation: Inverse-transform method, generation of random samples from various univariate probability distributions in R

Books Recommended:

1. Dalgaard, P. (2008). Introductory Statistics with R. Springer, 2nd edition.
2. Gentle, J.E. (2003). Random Number Generation and Monte Carlo Methods, Springer.
3. Rubinstein, R.Y. (1981). Simulation and the Monte Carlo Method, Wiley.
4. Venables, W. N. and Ripley, B. D. (2002). Modern Applied Statistics with S, Fourth Edition, Springer, New York.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VII)

PRACTICAL (BASED ON THEORY COURSES)

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: STATISTICS		
Course Code: STAT- 405F	**Course Title:** Practical (Based on theory courses)	
Credits: 0+4	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4		
Course outcomes: After completing this course a student will have: **CO1**. Ability of solving problem using different methods. **CO1**. Ability to solve problems based on STAT- 401F, STAT- 402F, STAT- 403F and STAT- 404F.		
Course prerequisites: To study this course, a student must have opted/passed the paper code STAT- 401F, STAT- 402F, STAT- 403F and STAT- 404F.		
Topic		
The practical for course code STAT- 405F is based on theory course STAT- 401F, STAT- 402F, STAT- 403F and STAT- 404F.		
Internal Evaluation Methods (Max. Marks: 25) Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance. {As prescribed by the University (as per common ordinance for examination and assessment)}.		
External Evaluation Methods (Max. Marks: 75) Practical External Evaluation shall be based on Viva-voce, Practical Exercises and Overall performance. {As prescribed by the University (as per common ordinance for examination and assessment)}.		

FOURTH YEAR (SEMESTER-VIII)

INFERENCE-I

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: STATISTICS		
Course Code: STAT- 406F	**Course Title:** Inference-I	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course, a student will be able to:

CO 1. Learn different estimation techniques.
CO 2. Learn properties of a good estimator.
CO 3. Learn to develop estimators for estimating population parameter.
CO 4. Learn basics of testing of hypothesis, calculation of type I and type II error.
CO 5. Understand Cramer Rao inequality, Rao Blackwell theorem, Lehmann – Scheffe theorem
CO 6. Learn the concept of MVBUE, MVUE, UMVUE.

Course prerequisites:

To study this course, a student must have passed Statistics as Major Subject in UG Third Year Programme.

Unit	Topics
I	Parametric models, Point estimation. Criteria of a good estimator: unbiasedness, consistency, efficiency and sufficiency. Concept of mean squared error. Fisher-Neyman factorization theorem, Family of distributions admitting sufficient Statistic. Point estimation methods: Likelihood functions, Maximum likelihood method (MLE) Examples from standard discrete and continuous models (such as Bernoulli, Poisson, Binomial, Normal, exponential, Gamma and uniform etc.)
II	Plotting Likelihood Functions for these models upto two parameters, moments and Least squares methods. Method of minimum chi-square and percentiles. Properties of maximum likelihood estimator. Successive approximation to MLE, Method of scoring and Newton-Raphson method. Cramer-Rao inequality and its attainment, Completeness and minimal sufficient statistic, Ancillary statistic, Basu theorem.
III	Uniformly minimum variance unbiased estimator (UMVUE). Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Statistical Hypothesis, critical region, types of errors, level of significance, power of a test, Test function, Randomized and non-randomized tests, Most powerful test and Neyman-Pearson lemma. MP test for simple null against simple alternative hypothesis.
IV	Extension of these results to distribution with MLR property, UMP tests for simple null hypothesis against one sided alternatives and for one sided null against one sided alternatives in a one parameter exponential family. MLR family of distributions, unbiased test. Uniformly most powerful unbiased test.

Books Recommended:

1. George Casella, Roger L. Berger, Statistical Inference, 2nd ed., Thomson Learning.
2. Mukhopadhyay P.: Mathematical Statistics, New central Book Agency (P) Ltd. Calcutta.
3. Rao, C.R.: Linear Statistical Inference and its Applications, 2nd ed, Wiley Eastern.
4. Goon, Gupta & Das Gupta: An Outline of Statistical Theory, Vol. II, World Press.
5. Hogg, R.V. and Craig, A.T.: Introduction to Mathematical Statistics, McMillan.
6. Kale, B.K. : A First Course on Parametric Inference, Narosa Publishing House.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VIII)
THEORY OF SAMPLE SURVEY

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: STATISTICS		
Course Code: STAT- 407F	**Course Title:** Theory of Sample Survey	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course, a student will be able to:

CO 1. Learn the basic concept of sampling and related terminologies.

CO 2. Understand various types of sampling schemes, with their advantages and disadvantages, and estimation of population parameters with their standard errors.

CO 3. Learn the use of auxiliary information in the ratio and regression method of estimation.

CO 4. Understand need of cluster and two stage sampling.

CO 5. Learn sampling with varying probabilities

CO 6. Understand some estimation techniques with special reference to non-response problems.

Course prerequisites:

To study this course, a student must have passed Statistics as Major Subject in UG Third Year Programme.

Unit	Topics
I	Basic finite population. Sampling techniques (SRSWR/SRSWOR, Stratified, Systematic) and related results on estimation of population mean/total. Allocation problem in Stratified sampling. Ratio method of estimation, optimum properties of ratio estimator, unbiased ratio type estimators, ratio method of estimation in stratified sampling.
II	Regression method of estimation, regression estimators, Product method of estimation. Cluster sampling with equal and unequal size clusters. Two-stage sampling: Two-stage sampling with equal number of second stage units, allocation of units at different stages.
III	Sampling with varying probabilities : PPS sampling wr/wor methods (including Lahiri's scheme) and related estimators of a finite population mean (Hansen-Hurwitz and Desraj estimators for a general sample size and Murthy's estimator for a sample of size 2).
IV	Horvitz-Thompson estimator (HTE) of a finite population total/mean; expressions for variance and its unbiased estimator; issue of non-negative variance estimation, IPPS schemes of sampling due to Midzuno-Sen. Randomized responses technique; Warner's model; related and questionnaire methods.

Books Recommended:

1. Chaudhuri, A. and Mukerjee, R. (1988): Randomized Response: Theory and Techniques. Marcel Dekker Inc.
2. Cochran, W.G.(1984): Sampling Techniques (3rd Edition, 1977). Wiley
3. Murthy, M.N.(1977): Sampling Theory & Methods. Statistical Publishing Society, Calcutta.
4. Sukhatme et al (1984): Sampling Theory of Surveys with Applications. Iowa State University Press & IARS.
5. Singh. D. and Chaudhary, F.S. (1986): Theory and Analysis of Sample Survey Designs. New Age International
6. Mukhopadhyay, P. (1996): Inferential problems in survey sampling. New Age Internetional (P).

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VIII)

MULTIVARIATE ANALYSIS

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: STATISTICS		
Course Code: STAT- 408F	**Course Title:** Multivariate Analysis	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course, a student will be able to:

CO 1. Develop the interrelationships between two or more sample objects

CO 2. Analyse the interrelationship of the variables along the maen and variance and some other characteristic related to univariate analysis.

CO 3. Estimate and interpret the extent or amount of relationship among the variables.

Course prerequisites:

To study this course, a student must have passed Statistics as Major Subject in UG Third Year Programme.

Unit	Topics
I	Multivariate Normal Distribution and its properties, Marginal and Conditional Distributions, Moment Generating and Characteristics functions.
II	Sample from multivariate normal distribution, unbiased estimators of Mean vector and Dispersion matrix, Maximum Likelihood Estimation of Mean vector and Dispersion matrix.
III	Hotelling's T^2 statistic, its pdf and properties. Wishart distribution and its properties. Mahalnobis D^2. Use of T^2 and D^2. Wilk's lambda.
IV	Canonical Correlation and variables, properties and their estimation. Principal Component of multivariate observation and its interpretation.

Books Recommended:

1. Anderson T.W. (1983): An Introduction its multination analysis. John Wiley & Sons.
2. Kshirsagar A.M. (1972): Multivariate Analysis. Marcel Dekker.
3. Giri N.C. (1977): Multivariate Statistical Inference, Academic Press.
4. Sharma, S. (1966): Applied Multivariate Techniques John Wiley & Sons.
5. Rao, C.R. (1973) : Linear Statistical Inference and its applications, John Wiley and Sons

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VIII)

OPERATIONS RESEARCH-I

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: STATISTICS		
Course Code: STAT- 409F	**Course Title:** Operations Research-I	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

After completing this course, a student will be able to:

CO 1. apply it in different sectors of research field like game theory, job sequencing, network analysis, dynamical programming etc.

CO 2. do their research work in different interdisciplinary areas.

CO 3. get hired by most of the companies as OR technician since companies require OR experts to get maximum output out of minimum resources.

Course prerequisites:

To study this course, a student must have passed Statistics as Major Subject in UG Third Year Programme.

Unit	Topics
I	Inventory Control: Introduction, Classification of Inventory, Economic parameter associated with inventory problems, Deterministic and Probabilistic models with without leadtime.
II	Sequencing Problems: Assumptions for sequencing problem. Processing n jobs on two machines, n jobs on three machines, 2 jobs on m machines, Problem of Replacement, Individuals and Group replacement policies.
III	Network analysis: Basic concepts and definition. Network drawing and analysis Critical pathmethod.Labellingmethod.Methodsbasedontimeestimatestofindcriticalpath.Conceptofslackand float. Resource levelling and time-cost trade-off analysis. Time-cost optimization procedure. Project crashing. PERT. Requirements for application of PERT technique. Practical limitations in using PERT. Differences in PERT and CPM.
IV	Non-Linear Programming: Introduction and definitions. Formulation of non-Linear programming problems, General non-linear programming problems. Kuhn-Tucker conditions, Lagrangian Method, Constrained optimization with equality constraints. Constrained optimization with inequality constraints. Saddle point problems Saddle points and NLPP. Wolfe's and Beale's method to solve Quadratic Progamming problem.

Books Recommended:

1. S.D.Sharma: Operations Research, Kedar Nath Ram Nath & Company.
2. S.S.Rao: Optimization Theory and Applications, Wiley Eastern Ltd.,New Delhi.
3. J.K.Sharma: Operations Research–Theory and Applications, Macmillan India Ltd.
4. H.A.Taha: Operations Research–An Introduction, Macmillan Publishing Co.,Inc.,New York.
5. Kanti Swarup, P.K.Gupta, ManMohan: Operations Research, Sultan Chand and sons, New Delhi.
6. B.S. Goel, S.K.Mittal: Operations Research, Pragati Prakashan ,Meerut.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VIII)

PRACTICAL (BASED ON THEORY COURSES)

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: STATISTICS		
Course Code: STAT- 410F	**Course Title:** Practical (Based on theory courses)	
Credits: 0+4	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4		
Course outcomes: After completing this course a student will have: **CO1**. Ability of solving problem using different methods. **CO1**. Ability to solve problems based on STAT- 406F, STAT- 407F, STAT- 408F and STAT- 409F.		
Course prerequisites: To study this course, a student must have opted/passed the paper code STAT- 406F, STAT- 407F, STAT- 408F and STAT- 409F.		
Topic		
The practical for course code STAT- 410F is based on theory course STAT- 406F, STAT- 407F, STAT- 408F and STAT- 409F.		
Internal Evaluation Methods (Max. Marks: 25) Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance. {As prescribed by the University (as per common ordinance for examination and assessment)}.		
External Evaluation Methods (Max. Marks: 75) Practical External Evaluation shall be based on Viva-voce, Practical Exercises and Overall performance. {As prescribed by the University (as per common ordinance for examination and assessment)}.		

FOURTH YEAR (SEMESTER-VIII)
DISSERTATION/ RESEARCH PROJECT

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: STATISTICS		
Course Code: STAT- 411F	**Course Title:** DISSERTATION/ RESEARCH PROJECT	
Credits:0+12	Core Compulsory	
Max. Marks: 100	**Min. Passing Marks:** As per University CBCS Norm	

Course Outcomes:

CO 1. The objective of course is to write a dissertation/research project on the specific topic.

CO 2. The student shall be able to do their research work in different interdisciplinary areas.

CO 3. After completing the course, the student shall be able to understand some advanced statistical techniques.

Course prerequisites:

To study this course, a student must have passed Statistics as Major Subject in UG Third Year Programme.

DISSERTATION/ RESEARCH PROJECT

Candidate/Students should write a dissertation/research project on the specific topic based on any one core/major papers opted by the student in any semester. The students has been allotted a supervisor in this dissertation/research project on their topic, given by the concern faculty. The dissertation/research project should be typed and its presentation on Power Point.

Evaluation Methods (Max. Marks: 100)

As prescribed by the University (as per common ordinance for examination and assessment).