DEPARTMENT OF STATISTICS

GAUHATI UNIVERSITY

Four Year Undergraduate Syllabus in Statistics under NEP
Effective from Academic Year 2023 – 24

Summary Structure

Semester	Course Code	Course Name	Credit
1	STA010104	Descriptive Statistics & Probability-I	4 (Theory 3 +Practical 1)
2	STA020104	Statistical and Numerical Methods	4 (Theory 3 +Practical 1)
3	STA030104	Survey Sampling- I & Design of Experiments-I	4 (Theory 3 +Practical 1)
4	STA040104	ProbabilityDistributions-I	4 (Theory 3 +Practical 1)
4	STA040204	Probability-II and Probability Distributions-II	4 (Theory 3 +Practical 1)
4	STA040304	Mathematical Methods	4 (Theory 3 +Practical 1)
4	STA040404	Linear Algebra	4 (Theory 3 +Practical 1)
5	STA050104	Applied Statistics-I	4 (Theory 3 +Practical 1)
5	STA050204	Sampling Distributions and Inference-I	4 (Theory 3 +Practical 1)
5	STA050304	Inference-II	4 (Theory 3 +Practical 1)
5	STA050404	Exact Sampling Distributions	4 (Theory 3 +Practical 1)
6	STA060104	Applied Statistics-II	4 (Theory 3 +Practical 1)
6	STA060204	Multivariate Analysis and Computer Programming	4 (Theory 3 +Practical 1)
6	STA060304	Operations Research	4 (Theory 3 +Practical 1)
6	STA060404	Design of Experiments-II	4 (Theory 3 +Practical 1)

Important Note: Prerequisite for major in Statistics is Minor in Mathematics

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	1	Descriptive Statistics & Probability-I	STA 010104	4	3	0	1	None	30	0	45	25

Course Level: 100-199
Number of Contact classes: 60
Number of Non-contact classes: 0

Course Objectives: The objective is to give students foundational ideas about the various statistical methods, measures of central tendency and basics of probability. The students are introduced to the methods of collecting data, their representational formats, and basic statistical tools.

Learning Outcomes: At the end of the course, students will be able to analyse a data set, represent the data in tabular and diagrammatic form, prepare the frequency distribution, find the summary measures viz. the measures of central tendency, measure of dispersion, measures of skewness and kurtosis of a univariate data.

Unit I: Statistical Methods: (No. of classes: 09, Weightage: 15%)
Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram and ogives, boxplot. Collection and Scrutiny of Data: Primary data-designing questionnaire and schedule; Secondary data- their Major sources including some government publications.

Unit 2: Measures of Central Tendency, Dispersion, and location: (No. of classes: 12, Weightage: 20%)

Mathematical measures of central tendency. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, skewness and kurtosis, relation between central and raw moments, cumulants, Sheppard's correction for moments, Deciles, percentiles, quartiles.

Unit 3: Probability - I: (No. of classes: 15, Weightage: 25%)

Introduction, random experiments, sample space, events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws ofaddition and multiplication, independent events, theorem of total probability, Bayes' theorem, and its applications.

Unit 4: Random variables and Expectations: (No. of classes: 9, Weightage: 15%)

Discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties. Expectation of univariate random variables.

Unit 5: Practical: (No. of classes: 15, Weightage: 25%)

Note: Students can use calculators / MS Excel / R programming as convenient**.**

1. Graphical representation of data.
2. Problems based on measures of central tendency & dispersion.
3. Problems based on measures of location.
4. Problems based on combined mean, variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.

SUGGESTED READINGS:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II,8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics withApplications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics,3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co.Ltd.
4. Medhi, J., Statistical Methods: An Introductory text (New Age International (P) Ltd.2000).

Course designed by : Amit Choudhury, Kishore Kr. Das and Rajan Sarma, Department of Statistics, Gauhati University.

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	2	Statistical and Numerical Methods	STA 020104	4	3	0	1	None	30	0	45	25

Course Level: 100-199
Number of Contact classes: 60
Number of Non-contact classes: 00

Course Objectives: The course will expose students to the need and nuances of correlation and basic probability distributions along with notions of Uncertainty and Randomness, Probability & Random variables, and Basic Data Analysis.

Learning Outcomes: At the end of the course, students will be able to apply the tools of correlation and model building in data analysis along with learning the use of basic probability distributions.

Unit 1: Bivariate data analysis: (No. of classes: 09, Weightage: 15%)

Definition, scatter diagram, Karl Pearson's correlation coefficient and its properties, partial and multiple correlation (3 variables only), rank correlation, correlation ratio.Simple linear regression, principle of least squares.

Unit 2: Basic Probability Distributions: (No. of classes: 12, Weightage : 20%)

Standard probability distributions: Binomial, Poisson, Uniform, Normal. Fitting ofthese distributions.

Unit 3 : Testing of Hypothesis - I: (No. of classes:12, Weightage : 20%)

Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region, size and power, Large sample tests, single mean, difference of two means (technique only; without derivation), t – test for testing single mean, difference of two means, paired t test (technique onlywithout derivation), F – test for testing equality of variance (technique only without derivation).

Categorical Data Analysis: Categorical data: Tests of proportions (testing single proportion, difference of two proportions,) tests of association, independence of attributes and goodness-of-fit using Chi- square Test (technique only without derivation),

Unit 4: Finite Difference: (No. of classes: 12, Weightage: 20%)
Definition, Operators Δ & E, their properties, Difference table, missing terms,

Interpolation: Definition, Newton's Forward and Backward interpolation formula, Gauss Interpolation formula. Divided Difference (DD): Definition, DD table, Newton's DD formula. Lagrange's interpolation formula. Numerical Integration: Introduction, General quadrature formula, Trapezoidal, Simpson's 1/3rd & 3/8th rules, Newton-Raphson method.

Unit 5 : Practical (No. of classes: 15, Weightage : 25%)

Note : Students can use calculators / Ms Excel / R programming as convenient.

1. Fitting of binomial distributions for n and p=q =½.
2. Fitting of binomial distributions for given n and p.
3. Fitting of binomial distributions after computing mean and variance.
4. Fitting of Poisson distributions for given value of lambda.
5. Fitting of Poisson distributions after computing mean.
6. Problems based on area property of normal distribution.
7. To find the ordinate for a given area for normal distribution.
8. Fitting of normal distribution when parameters are given.
9. Fitting of normal distribution when parameters are not given.
10. Practicals on Unit-1
11. Practicals on Unit-3
12. Practicals on Unit-4

***SUGGESTED READINGS*:**

1. Goon,A.M.,Gupta,M.K.andDasgupta,B.(2003): An Outline of Statistical Theory, Vol.I, 4th Edn. World Press, Kolkata.

2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability andStatistics. 2nd Edn. (Reprint) John Wiley and Sons.
3. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K.(2001): Statistics-Principles and Methods, 4thEdn. John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory ofStatistics, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd.

Course designed by : Rajan Sarma, Department of Statistics, Gauhati University.

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	3	Survey Sampling-I & Design of Experiments-I	STA 030104	4	3	0	1	None	30	0	45	25

Course Level: 200-299
Number of Contact classes: 60
Number of Non-contact classes: 0
Prerequisites: NIL

Course Objective: This course is designed to provide students with knowledge aboutthe techniques of data collection.

Learning Outcomes: At the end of the course, students will be able to know the basic designs of sampling schemes.

Unit1: Survey Sampling - I: (No. of classes: 09, Weightage: 15%)

Complete enumeration, controlled experiments, observational studies and sample surveys, Concept of population and sample, complete enumeration versus sampling, concept of sampling frame, principal steps in a sample survey, sampling and non-sampling errors. Types of sampling:non-probability and probability sampling, basic principle of sample survey.

Unit 2: Simple random sampling: (No. of classes: 06, Weightage: 10%)

Simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and mean square. Determination ofsample size-preliminary formulas only.

Unit 3: Stratified random sampling and Systematic Sampling: (No. of classes: 15, Weightage: 25%)

Technique of stratified sampling, estimates of population mean and total (without derivation), variances of these estimates (without derivation), proportional allocations, determination of sample size (in case of proportional allocation only).

Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=n x k) (Comparison of systematic sampling with other sampling schemes not required).

Unit 4: Design of Experiments – I: (No. of classes: 15, Weightage: 25%)

One way and two-way ANOVA.

Basic principles of Design, Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD)– layout, model and statistical analysis (without derivations), (analysis with missing observations not required).

Unit 5: Practical (No. of classes: 15, Weightage: 25%)

Note: Students can use calculators / MS Excel / R programming as convenient.

List of Practicals: Practicals on Unit-2, 3 & 4.

SUGGESTED READINGS:

1. Cochran, W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern.

2. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok,C.(1984). Sampling Theories of Survey

With Application, IOWA State University Press and Indian Society of Agricultural Statistics

3. Murthy, M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society,Calcutta.

5. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2001): Fundamentals of Statistics (Vol.2),World

Press.

6. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.

7. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.

8. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.

Course designed by : Rajan Sarma, Pallabi Medhi, Arpita Basak Dept of Statistics, GU .

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	4	Probability Distributions-I	STA040104	4	3	0	1	None	30	0	45	25

Course Level: 200-299
Number of Contact classes: 60
Number of Non-contact classes: 00

Course Objectives: This course has the objectives of

(1) providing exposure to functions of random variables like their distribution functions, moments, cumulants and their generating functions.
(2) Demonstrating the concept of two dimensional random variables along with the idea of Bivariate transformation.
(3) Understanding the notion of independence between random variables and concepts of conditional expectation and variance.
(4) Understanding order Statistics and their marginal and joint distributions.
(5) Introducing the concept of Stochastics Processes, especially Markov Chains and their Properties.

Learning Outcomes: At the end of the course, the student will be able to

(1) Determine the moments, conditional and unconditional mean and variance of the functions of one dimensional as well as two dimensional random variables.
(2) Determine the marginal distribution of r^{th} order statistics and joint distribution of r^{th} and s^{th} order statistics and the distributions of sample mean and median.
(3) Interpret the TPM of a Markov chain, compute higher transition Probabilities, classify states of Markov chains, interpret a counting process as a Poisson process and compute its probabilities

Unit 1: **Functions of Random variables**: (No. of classes: 15, Weightage: 25%)

Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, bivariate transformations, conditional expectations, conditional variance.

Moments, factorial moments, Cumulants, Generating functions – mgf, pgf, cgf together with their properties.

Unit 2: Order Statistics: (No. of classes: 15, Weightage: 25%)

Introduction, distribution of the r^{th} order statistic, smallest and largest order statistics. Joint distribution of r^{th} and s^{th} order statistics, distribution of sample median and sample range.

Unit 3: Stochastic Process: (No. of classes: 15, Weightage: 25%)

Stochastic Process: Introduction, Stationary Process. Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains. Poisson Process: postulates of Poisson Process, properties of Poisson Process with applications.

Unit 4: Practical: (No. of classes: 15, Weightage: 25%)
Practical from unit 1 and 3.

SUGGESTED READINGS:

1. Chung, K.L. (2000): A course in Probability Theory (3rd Edition), Academic press.
2. David, H.A and Nagaraja, H.N. (2003): Order Statistics (3rd Edition), Wiley Series in Probability and Statistics.
3. Gupta, S.C and Kapoor, V.K. (2020): Fundamental of Mathematical Statistics (10th Edition), Sultan Chand and Sons.
4. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
5. Medhi, J. (2002): Stochastic Processes (2nd Edition), New Age International(P) LTD, Publishers, New Delhi.
6. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
7. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.
8. Ross, S.M. (2009): Introduction to Probability Models, (10th Edition), Academic Press, An imprint of Elsevier

Course designed by : Kishore Kr Das and Rajan Sarma Dept of Statistics, GU .

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	4	Probability-II and Probability Distributions-II	STA040204	4	3	0	1	Mathematics Minor	30	0	45	25

Course Level : 200-299
Number of Contact classes : 60
Number of Non contact classes:00

Course Objective: This course has the objective of providing exposure to probability theory and various discrete and continuous probability distributions with their applications. This course also introduces the concept of bi-variate distribution and their properties.

Learning Outcomes: At the end of the course, students shall be able to apply various theorems on probability. Along with the preliminary knowledge on bi-variate distribution, they shall also be able to know the functional form of various discrete and continuous probability distributions and their characterizations.

Unit 1: Probability– II: (No. of classes: 15, Weightage: 25%)

Chebyshev's Lemma (with proof), Weak Law of Large Numbers (WLLN) due to Bernoulli, Khintchine and Liapounov. Central Limit Theorem (CLT)-De-Moivre's and Lindeberg-Levy CLT (with proof).

Unit 2: Probability Distributions - II: (No. of classes: 30, Weightage: 50%)

Multinomial, Geometric, Negative Binomial, Hypergeometric, Exponential, Weibull, Cauchy, Beta and Gamma distributions along with their properties and limiting/approximation cases, Lognormal.

Normal distribution – harder problems and theory (over and above what is covered in unit

2 of paper STA201).

Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.

Unit 3: Practical: (No. of classes: 15 ,Weightage: 25%)

Practicals from Unit 2.

SUGGESTED READINGS:

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference,Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statisticswith Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford &IBH Publishing, New Delhi

Course designed by : Kishore Kr Das and Rajan Sarma Dept of Statistics, GU .

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	4	Mathematical Methods	STA040304	4	3	0	1	Mathematics Minor	30	0	45	25

Course Level : 200-299

Number of Contact classes : 60

Number of Non contact classes : 0

Course Objective: This course has the objective of providing student with the necessary mathematical basics of Calculus and Numerical Analysis necessary for certain domains of Statistics.

The course has the objective of

(1) Providing exposure to relatively advanced skills in calculus like finding differentiation of indeterminant forms, carrying out constrained and unconstrained optimization and evaluating Beta and Gamma integrals.

(2) Equipping the students with the different methods of solving differential equations and carrying out different tests to identify whether an infinite series is convergent or not.

(3) Explaining the different types of interpolation for a series of observations and different methods of finding the approximate solution to a transcendental equation.

Learning Outcomes: At the end of the course, students shall be able to use the Mathematical results of Calculus and Numerical analysis to different scenarios of a statistical problem specifically those requiring evaluation of infinite integrals, conducting optimization and finding numerical solution of a transcendental equation and interpolation.

Unit1: Calculus: (No. of classes: 18, Weightage: 30%)

Indeterminate forms: L-Hospital's rule, Maxima and minima of functions of oneand two variables, constrained optimization techniques (with Lagrange's multiplier)

along with some problems. Jacobian- transformation of variables. Beta and Gamma functions: properties and relationship between them.

Exact differential equations, integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals.

Unit 2 : Infinite Series: (No. of classes: 06,Weightage: 10%)
Infinite series, positive termed series and their convergence; Comparison test, D'Alembert's ratio test, Cauchy's n^{th} root test, Raabe's test (For all the tests, statementonly is required, without proof. Applications only).

Unit 3: Numerical Analysis: (No. of classes: 21, Weightage: 35%)

Factorial notation, Zero differences, Central differences due to Bessel. Stirling's approximation to factorial n. Solution of difference equations of first order, Numerical methods for determination of approximate solutions of equations – Regula Falsi method, Bisection method.

Unit 4: Practical: (No. of classes: 15, Weightage: 25%)
Practicals from unit 3.

SUGGESTED READINGS:

1. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14^{th}Edition-1997).
2. Gorakh Prasad: Integral Calculus, Pothishala Pvt. Ltd., Allahabad (14^{th}Edition-2000).
3. Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt.Ltd., New Delhi
4. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.
5. Bartle, R. G. and Sherbert, D.R. Introduction to Real Analysis (John Wiley and Sons,New Delhi, 2007).
6. Simmons, G.F. Differential Equations with Applications and Historical Notes (TataMcGraw- Hill, New Delhi, 1991).
7. Malik, S.C. (2021): Principles Of Real Analysis (5^{th} Edition), New Age International Publishers.
8. Narayan, S and Raisinghania, M.D. (2003): Elements of Real Analysis, S. Chand.
9. Burden, R.L. and Faires, J.D.(2007): Numerical Analysis, 7^{th} Edition, Thomson, Brooks/Cole.

Course designed by : Amit Choudhury, Rajan Sarma, Dept of Statistics, GU .

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	4	Linear Algebra	STA040404	4	3	0	1	Mathematics Minor	30	0	45	25

Course Level: 200-299
Number of Contact classes: 60
Number of Non-contact classes: 0

Course Objective: This course has the objective of providing student with the necessary mathematical basics on matrices, vector space and systems of linear equations.
Learning Outcomes: At the end of the course, students shall be able to explain the basics of matrices, vector space and shall be capable of solving the numerical problems based on matrices in addition to solving systems of linear equations.

Unit 1: Linear Algebra: (No. of classes: 21, Weightage: 35%)

Rank of a matrix, standard theorems on ranks, rank of the sum and the product oftwo matrices. Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms, Linear orthogonal transformation and their diagonalization.

Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem.

Unit 2: Determinants and System of Linear Equations: (No. of classes: 24, Weightage: 40%)

Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skewsymmetric determinants, Jacobi's Theorem, product of determinants. Use of determinants in solution of linear equations, the system of linear equations, row reduction and echelon forms, the matrix equations AX=B, solution of linear equations, linear independence, Applications of linear equations, inverse of a matrix.

Unit 3: Practical: (No. of classes: 15, Weightage: 25%)

Practicals from unit 1 and 2.

***SUGGESTED READINGS*:**

1. Lay David C.: Linear Algebra and its Applications, Addison Wesley ,2000.
2. Schaum's Outlines: Linear Algebra, Tata McGraw-Hill Edition, 3rd Edition, 2006.
3. Krishnamurthy, V., Mainra, V.P. and Arora J.L.: An Introduction to Linear Algebra (II,III, IV, V).
4. Jain, P.K. and Khalil Ahmad: Metric Spaces, Narosa Publishing House, New Delhi,1973
5. Biswas, S.(1997): A Textbook of Matrix Algebra, New Age International, 1997.
6. Gupta,S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons, 2008.
7. Artin, M.: Algebra. Prentice Hall of India, 1994.
8. Datta, K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.
9. Hadley, G.: Linear Algebra, Narosa Publishing House (Reprint), 2002.
10. Searle, S.R.: Matrix Algebra Useful for Statistics. John Wiley & Sons., 1982.

Course designed by: Jagriti Das, Rajan Sarma, Kishore Kr Das, Dept of Statistics, GU .

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	5	Applied Statistics-I	STA 050104	4	3	0	1	None	30	0	45	25

Course Level : 300-399
Number of Contact classes : 60
Number of non-contact classes: 00

Course Objective: This course has the objective of imparting knowledge to students about the statistical concepts in four important applied statistical fields – Time series, statistical quality control, demography and official statistics so that they are able to utilize these notions in solving real life problems.

Learning Outcomes: At the end of the course, students are expected to develop a clear understanding of the basic concepts of Time series, statistical quality control, demography and official statistics. They should be able to apply these statistical tools to analyze real life time series or demographic data. They should be also able to apply the SQC methods to data arising in industry and should be familiar with how the Indian official statistical system works.

Unit 1: Time Series: (No. of classes: 15, Weightage: 25%)

Economic Time Series: Components of time series, Decomposition of time series-Additive and multiplicative model with their merits and demerits, Illustrations of time series. Measurement of trend by method of free-hand curve, moving average method, method of semi-averages and method of least squares (linear, quadratic and modified exponential), Measurement of seasonal variations by method of ratio to trend.

Unit 2: Statistical Quality Control: (No. of classes: 15, Weightage: 25%)

Statistical Quality Control: Importance of statistical methods in industrial research and practice. Rational subgroup., Determination of tolerance limits. Causes of variations in quality: chance and assignable.

General theory of control charts, process & product control, Control charts for variables: X- bar, R-charts and sigma chart. Control charts for attributes: p and c-charts. Product control – basic ideas of Single sampling and double sampling plans.

Unit 3: Demography and official Statistics: (No. of classes: 15, Weightage: 25%)

Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates. Life (mortality) tables: definition of its main functions and uses – differences between complete and abridged life table.

Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

Present Official Statistical System in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal Publications containing data on the topics suchas population, Industry, Economy, Development and Finance.

Unit 4: Practical: (No. of classes: 15, Weightage:25%)

Practicals from unit 1,2 and 3

***SUGGESTED READINGS*:**

1. Chatfield, C. (1980). The Analysis of Time Series –An Introduction, Chapman & Hall.
2. Goon, A. M., Gupta, M. K. and Dasgupta, B. (2003). Fundamentals of Statistics, 6th Ed., Vol II Revised, Enlarged.
3. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.
4. Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons.
5. Kendall, M.G. (1976). Time Series, 2nd Ed., Charles Griffin and Co Ltd., London and High Wycombe.
6. Montgomery, D. C. and Johnson, L. A. (1967). Forecasting and Time Series Analysis, 1st Ed. McGraw-Hill, New York.
7. Mukhopadhyay, P. (2011). Applied Statistics, 2nd Ed., Revised reprint, Books and Allied Pvt. Ltd.

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	5	Sampling Distributions and Inference-I	STA050204	4	3	0	1	Mathematics Minor	30	0	45	25

Course Level: 300-399
Number of Contact classes: 60
Number of Non-contact classes: 0

Course Objectives: This course has the objective of enabling students to

(1) Review the various concepts of sampling and their utility in Statistics.
(2) Understand the concepts of variability in Sample measures and their distributions.
(3) Review and appreciate the various tests of significance (for large samples) for attributes and variables.
(4) Understand the basic differences between a parametric and nonparametric test and when and how to conduct various nonparametric tests.

Learning Outcomes: At the end of the course, the student should be able to

(1) Demonstrate the concept of parameter, sampling distribution of Statistic and its standard error and their utility in testing of significance for large samples.
(2) Characterize, conduct and compare different nonparametric tests for hypothesis.

Unit 1: Sampling Distributions and Large Sample Tests: (No. of classes: 21, Weightage: 30%)

Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean,sample variance and sample proportion.

Review of Large sample tests, testing single proportion, difference of two proportions.

Unit 2: Non-parametric Tests: (No. of classes: 27,Weightage: 45%)

Nonparametric Tests: Introduction and Concept, Concept of Distribution free procedure, Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov-Smirnov test for one and two sample (without proof), Sign tests-one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test – all without derivation.

Unit 4: Practical: (No. of classes: 15, Weightage: 25%)

Practical from unit 1 and 2.

SUGGESTED READINGS:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory,(Vol. I, 4th Edition) World Press, Kolkata.
2. Rohatgi V.K. and Saleh, A.K. Md.E. (2009): An Introduction to Probability and Statistics. (2nd Edition Reprint) John Wiley and Sons.
3. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in MathematicalStatistics. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, (4th Edition) John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edition Reprint). Tata McGraw-Hill Pub. Co. Ltd.
6. Gibbons, J.D. and Chakraborti, Subhabrata (2010): Nonparametric Statistical Inference (5th Edition), CRC Press, Taylor & Francis Group.
7. Gupta, S.C and Kapoor, V.K. (2020): Fundamental of Mathematical Statistics (10th Edition), Sultan Chand and Sons.

Course designed by : Kishore Kr Das, Rajan Sarma, Dept of Statistics, GU

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	5	Inference-II	STA 050304	4	3	0	1	Mathematics Minor	30	0	45	25

Course Level: 300-399
Number of Contact classes: 60
Number of Non-contact classes: 0

Course Objective: This course has the objective of exposing students to the concepts of estimation and testing of hypothesis - its types, and desirable properties of an estimator and **the procedure** to find a good estimate from a sample data.

Learning Outcomes: At the end of the course, students shall be able to

i) determine a good estimate,

ii) examine the properties of estimators and

iii) test different types of statistical hypothesis.

Unit 1: Estimation: (No. of classes: 24, Weightage: 40%)

Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency, Factorization theorem, Minimum variance unbiased estimator (MVUE). Cramer-Rao inequality and MVB estimators.

Methods of estimation - Method of moments, method ofmaximum likelihood estimation.

Unit 2: Hypothesis Testing II (No. of classes: 21, Weightage: 35%)

Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region- harder problem and concepts (over andabove what is covered in unit 3 of paper STA 201). Testing of hypothesis based on traditional and p-value approach

MP test, UMP test, unbiased test, Neyman Pearson Lemma (with proof) and ituse, power

curve. Likelihood ratio test, properties of likelihood ratio tests (without proof).

Unit 3: Practical (No. of classes: 15, Weightage: 25%)

Practicals from Unit 1 and 2

SUGGESTED READINGS:

1. Goon, A.M., Gupta, M.K.: Das Gupta, B. (2005), Fundamentals ofStatistics, Vol. I, World Press, Calcutta.
2. Rohatgi, V.K. and Saleh, A.K. Md.E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002): John E.Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988): Modern MathematicalStatistics. John Wiley & Sons.
5. Mood, A.M, Graybill, F.A. and Boes, D.C,: Introduction to the Theory of Statistics, Mc Graw Hill.
6. Snedecor, G.W and Cochran, W.G. (1967) Statistical Methods. Iowa State University Press.

Course designed by : Rajan Sarma, Jagriti Das, Sahana Bhattacharjee, Dept ofStatistics, GU .

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	5	Exact Sampling Distributions	STA050404	4	3	0	1	Mathematics Minor	30	0	45	25

Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes: 0

Course Objectives: This course has been designed with the objective of familiarizing the students with the important exact sampling distributions, their properties, and applications.

Learning Outcomes: After completion of this course, students should be able to gather idea about the major exact sampling distributions and apply these distributions in real life hypothesis testing problems.

Unit 1: Exact sampling distributions- Chi square distribution: (No. of classes: 15, Weightage: 25%)

Definition and derivation of p.d.f. of $\chi^2$with n degrees of freedom (d.f.) using m.g.f., nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of χ^2distribution.Applications of this distribution, Tests of significance and confidence intervals based on distribution. Non central chi square distribution (derivation of pdf).

Unit 2: Exact sampling distributions- t distribution: (No. of classes: 15,

Weightage: 25%)

Student's and Fishers t- distribution, Student's and Fisher's t distribution, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution, Applications of this distribution**.** Non Central t distribution (with derivation of pdf).

Unit 3: Exact sampling distributions- F distribution: (No. of classes: 15, Weightage: 25%)

Snedecor's F -distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Distribution of 1/F(n1,n2). Relationship between t, F and χ^2 distributions, Applications of this distribution. Test of significance and confidence Intervals based on t and F distributions. Non Central F distribution (with derivation of pdf)

Unit 4: Practical (No. of classes: 15, Weightage: 25%)

Practicals from unit 1,2 and 3

***SUGGESTED READINGS*:**

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
2. Hogg, R.V. And Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
3. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
4. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd.
5. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.

Course designed by : Dept of Statistics, GU

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	6	Applied Statistics-II	STA060104	4	3	0	1	None	30	0	45	25

Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes : 00

Course Objective: This course has the objective of exposing students the different domains of applied statistics.

Learning Outcomes: At the end of the course, students shall be able to understand how statistics is directly applied in economic analysis, govt. and society. Students shall also be able to know various sampling techniques and gain the ability to select appropriate method in field survey.

Unit 1: Index Numbers: (No. of classes: 12, Weightage: 20%) Index numbers: Definition, Uses and limitations of index numbers. Criteria/tests for a good index number, different types of index numbers- price,quantity, value. Wholesale price index number, Index of Industrial Production.

Construction of index numbers of prices and quantities – Laspeyres', Paasche's,Fisher's and Marshal-Edgeworth's Index numbers. Consumer price index number.

Unit 2: Demand Analysis: (No. of classes: 9, Weightage: 15%)
Demand Analysis: Theory of consumption and demand, demand function, elasticity of

demand, determination of elasticity of demand by family budgetmethod, Lorentz curve and Gini coefficient, Engel's law and Engel's curve,Pareto's law of income distribution.

Unit 3: Regression Analysis: (No. of classes: 06, Weightage: 10%)

Simple regression analysis, Estimation and hypothesis testing in case of simple regression models.

Unit 4: Survey Sampling – II: (No. of classes: 18, Weightage: 30%)
Concept of population and sample, need for sampling, complete enumeration versus sampling, basic concepts in sampling, sampling and non-sampling errors, Simple random sampling with and without replacement, estimation of population mean, population proportions and their standard errors. Determination of sample size.

Stratified random sampling, proportional and optimum allocation, comparison with simple random sampling for fixed sample size, determination of sample size for proportional and optimum allocation.

Ratio and regression methods of estimation, estimation of population mean, comparison with simple random sampling.

Systematic sampling (Linear systematic sampling and circular systematic sampling), procedure of selecting a sample using LSS and CSS, Estimation of population mean and standard error of this estimate, comparison with simple random sampling and stratified random sampling.

Elementary idea of cluster sampling.

Unit 5: Practical (No. of classes: 15, Weightage: 25%)

Practicals from Unit 1, 3, and 4

SUGGESTED READINGS:

1. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II,9th Edition World Press, Kolkata.
2. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 4th Edition (Reprint), Sultan Chand & Sons.
3. Mukhopadhyay, P. (1999): Applied Statistics, Books and Allied(P) Ltd.
4. Cochran, W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern.
5. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok,C.(1984). Sampling Theories ofSurvey With Application, IOWA State University Press and Indian Society of Agricultural Statistics
6. Murthy, M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	6	Multivariate Analysis and Computer Programming	STA060204	4	3	0	1	Mathematics Minor	30	0	45	25

Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes: 00

Course Objective: This course aims to expose students to the theoretical concepts of multivariate normal distributions, their properties and applications. It also has the objective of acquaint the students with the idea of basic computer programming using C programming language.

Learning Outcomes: At the end of the course, students should be able to develop a clear understanding of the concepts of multivariate normal distributions along with their properties and should be able to apply these ideas to real life problems. Furthermore, they should be able to grasp the nuances of C programming language which may help them to switch to any other programming language in future.

Unit 1: Multivariate Normal Distributions: (No. of classes: 21, Weightage: 35%)

Multivariate Data: Higher Dimensional Random Variable: Probability mass/ density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions and Multiple correlation for n variables.

Multivariate Normal distribution and its properties. Marginal and conditional

distribution, Sampling distribution for mean vector and variance- covariance matrix without derivation). Hotelling T^2–concept and applications.

Unit 2: Computer Programming in C (No. of classes: 24, Weightage: 40%)

History and importance of C. Components, basic structure programming, character set, Keywords and Identifiers and execution of a C program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constant.

Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression.

library functions. Decision making and branching - if…else, nesting of if…else, else if, Looping in C: for, nested looping. Pointers, Structures, User defined functions.

Unit 3: Practical: (No. of classes: 15, Weightage: 2 5 %)

Practicals from Unit 1.

SUGGESTED READINGS:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley.
2. Balagurusamy, E. (2011). Programming in ANSI C, Ed., and Tata McGraw Hill.
3. Gottfried, B.S. (1998). Schaum's Outlines: Programming with C, 2nd Ed., Tata McGraw Hill.
4. Johnson, R.A. And Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn., Pearson & Prentice Hall.
5. Kernighan, B.W. and Ritchie, D. (1988). C Programming Language, 2nd Ed., Prentice Hall.
6. Kshirsagar, A.M. (1972): Multivariate Analysis, 1stEdn. Marcel Dekker.
7. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
8. Mukhopadhyay, P.: Mathematical Statistics.

Course designed by : Rajan Sarma and Paramita Roy, Dept of Statistics, GU .

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	6	Operations Research	STA060304	4	3	0	1	Mathematics Minor	30	0	45	25

Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes : 00

Course Objective: This course has the objective of inculcating the skills of Operations Research.

Learning Outcomes: At the end of the course, students shall be able to use techniques of operations research to obtain optimization in field level problems.

Unit 1: Linear Programming Problem: (No. of classes: 12, Weightage: 20%)

Linear Programming Problem, Mathematical formulation of LPP, Graphical solution of an LPP, Simplex procedure for solving LPP (without derivation) (three or more variables), slack and surplus variable.

Unit 2: Transportation problem: (No. of classes: 06, Weightage: 10%)

Transportation Problem, Initial solution by North West corner rule, Least cost method.

Unit 3: Replacement problem: (No. of classes: 09, Weightage:15%)

Replacement of items with deterministic deterioration (items that deteriorate with time), case of money value changing with time, group replacement policy.

Unit 4: Network problems-CPM & PERT: (No. of classes: 12, Weightage: 20%)

Conception of network, idea of network node, activities, dummy activity, constructionof network diagram. Network scheduling using C.P.M: determination of different types of floats and slacks, determination of critical path.

Unit 5 : Inventory Control: (No. of classes: 06, Weightage:10%)

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations (with and without shortages).

Unit 6: Practical: (No. of classes: 15, Weightage:25%)

Practicals from Unit 1, 2 and 4.

SUGGESTED READINGS:

1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
2. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
3. Hadley, G: (2002) : Linear Programming, Narosa Publications
4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to OperationsResearch Concepts and cases, 9th Edition, Tata McGraw Hill

Course designed by: Amit Choudhury, Rajan Sarma, SahanaBhattachrjee, Dept of Statistics, GU .

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks		External Marks	
						Lecture	Tutorial	Practical		Theory	Practical	Theory	Practical
FYUGP in Statistics (Major/Minor)	No	6	Design of Experiments-II	STA060404	4	3	0	1	Mathematics Minor	30	0	45	25

Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes:0

Course Objective: This course has the objective of providing student the knowledge of art of analysis.

Learning Outcomes: At the end of the course, students shall be able to understand the different types of commonly used field experimental techniques.

Unit 1: Analysis of Variance: (No. of classes: 15, Weightage: 25%)

Definitions of fixed, random and mixed effect models, analysis of varianceand covariance in one-way classified data for fixed effect models, analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect models.

Unit 2: Design of Experiments-II: (No. of classes: 15, Weightage: 25 %)
Role, historical perspective**,** terminology, experimental error, basic principles, uniformity trials, choice of size and shape of plots and blocks. Review of Completely Randomized Design (CRD), Randomized Block Design (RBD) – one observation and more than one observation per cell (Complete statistical analysis with derivation), Latin Square Design (LSD) layout, model and statistical analysis, relative efficiency, analysis with missing observation (one missing observation), Split Plot Design, Strip Plot Design.

Unit 3: Factorial Experiments – II: (No. of classes: 15, Weightage: 25 %)

Factorial experiments: advantages, notations and concepts, 2^2, 2^3, . . . , 2^n and 3^2 factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 5$) experiment.

Unit4: Practical: (No. of classes: 15, Weightage: 25%)

Practical from Unit 1, 2 and 3.

SUGGESTED READINGS:

1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8th Edn. World Press, Kolkata.
4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
5. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley
6. Goon, A.M., Gupta, M.K., Das Gupta, B. (2005), Fundamentals of Statistics, Vol.I, World Press, Calcutta.

Course designed by: Arpita Basak, Paramita Roy, Dept of Statistics, GU