Detailed Syllabus for Semesters I B.Sc. StatisticsCourse Content of Semester– I

STCT 101 -Descriptive Statistics

Course Title: **Descriptive Statistics**	Course Credits:4
Total Contact Hours:56	Duration of ESA: 2 hours
Formative Assessment Marks:40	Summative Assessment Marks:60

Number of Theory Credits	Number of lecture hours/semester	Number ofpractical Credits	Number of practical hours/semester
04	**56**	**02**	**52**

Content of Theory Paper 1	**56 hrs**
Unit–1:Introduction to Statistics	**13 hrs**
Statistics: Definition and scope. Data: quantitative and qualitative, cross sectional and time-series, discrete and continuous variable. Scales of measurement :nominal, ordinal, interval and ratio. Data organization, Visualization: Tabular and graphical. Frequency distributions, cumulative frequency distributions and their graphical representations. Stem and leaf displays. Concepts of population and sample. Methods of sampling- SRS, Stratified, Systematic and Cluster sampling methods: definitions only.	
Unit–2:Univariate Data Analysis	**18 hrs**
Concept of measures of central tendency : Arithmetic Mean, weighted mean, trimmed mean, Median,Mode, Geometric and harmonic means, properties, merits and limitations, relation between these measures. Measures of dispersion: Range, Quartile deviation, Mean deviation, Standard deviation and their relative measures. Gini's Coefficient, Lorenz Curve. Moments, Skewness and Kurtosis. Partition Values and measures based on them. Box Plot. Outliers.	

Unit –3:Bivariate Data Analysis	**12 hrs**
Bivariate Data-,Correlation: Meaning, Types. Methods- Scatter plot, Karl Pearson's correlation coefficient, Rank correlation: Spearman's and Kendall's measures. Functional relation between the variables, concept of errors, principle of least squares, Simple linear regression and its properties. Fitting of linear regression line and coefficient of determination their interpretation. Fitting of polynomial and exponential curves.	
Unit –4:Multivariate Data Analysis	**13 hrs**
Analysis of Categorical Data: Contingency table, independence and association of attributes, measures of association-odds ratio, Pearson's and Yule's measure, Multivariate Frequencies, Multivariate Data Visualization, mean vector and dispersion matrix, Multiple linear regression, multiple and partial correlation coefficients. Residual variance.	

Self -Study Components :

- Types of data – Primary data and secondary data
- Preparation of Questionnaire for Sample Surveys using google forms.
- Basic Data Visualization Tools.

References

1. Agresti,A.(2010).Analysis of Ordinal Categorical Data,2nd Edition,Wiley.
2. Anderson T.W.and Jeremy D.Finn(1996).The New Statistical Analysis of Data,Springer
3. Freedman,D.,Pisani,R.andPurves,R.(2014).Statistics,4thEdition,W.W.Norton & Company.
4. Gupta,S.C.(2018).Fundamental of Statistics, Himalaya Publishing House,7thEdition.
5. Gupta S.C. and V.K. Kapoor (2020). Fundamental of Mathematical Statistics, Sultan Chandand Co. 12thEdition.
6. Hogg, R. V. McKean J. W. and Craig, A. T. (2012). Introduction toMathematical Statistics,Pearson 7thEdition.
7. Joao Mendes Moreira,Andre CPL Fde Carvalho,Tomas Horvath(2018).General Introduction to Data Analytics, Wiley.
8. Johnson, R.A. and Bhattacharyya, G.K. (2006). Statistics: Principles and methods. 5thEdition,John Wiley & Sons, New York.

9. Medhi,J.(2005).Statistical Methods,New Age International.
10. Ross, S.M. (2014). Introduction to Probability and Statistics for Engineers and Scientists,5thEdition,Academic Press.
11. Tukey,J.W.(1977). Exploratory Data Analysis, Addison-Wesley Publishing Co.

Pedagogy

- The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
- Students are encouraged to use resources available on open sources.

STCP101: Practical 1 **4 Hrs Per week**

List of Experiments

(Carrying-out all the practicals manually as well as using Excel spread sheet)

1. Presentation of data by frequency tables, diagrams and graphs, stem and leaf, partition values.
2. Arithmetic Mean (AM),geometric mean, harmonicmean, weighted AM, trimmed mean, corrected mean.
3. Mode, median, partition values.
4. Absolute and relative measures of dispersion, Boxplots.
5. Problems on moments, skewness and kurtosis.
6. Fitting of curves by least squares method.
7. Product moment correlation coefficient and rank correlation.
8. Fitting Simple Linear Regression
9. Partial and Multiple correlation.
10. Problems on Association of attributes.

OPEN ELECTIVE-: STOE101: APPLIED STATISTICS

Course Title: Applied Statistics	Course Credits:3
Total Contact Hours:42	Duration of ESA:2 hours
Formative Assessment Marks:40	Summative Assessment Marks:60

Course Objectives

- To enable the students to use statistical tools in finance, industries, population studies and health sciences.
- To acquire knowledge about sampling methods for surveys.

Course Outcomes (COs)

Upon successful completion of this course, the student will be able to:

CO1.Understand the Price and Quantity Index numbers and their different measures,understand theapplicability of cost of living Index number.

CO2.Know the components and Need for Time series, understand the different methods of studying trend and SeasonalIndex.

CO3.Studytheconceptofvitalstatistics,sourcesofdata,differentmeasuresofFertilityandMortality, Understand the Growth rates-GRR and NRR and their interpretations.

CO4.Know the concept of Population, Sample, Sampling unit, sampling design, sampling frame,sampling scheme, need for sampling , apply the different sampling methods for designing andselecting a sample from a population, explain sampling and non-sampling errors.

CO5.Describe the philosophy of statistical quality control tools as well as their usefulness in industry and hence develop quality control tools in a given situation.

Pedagogy

- The course is taught using traditional chalk and talk method using problem solving throughexamples and exercises.
- Students are encouraged to use resources available on open sources.

Unit1:EconomicStatistics 15Hour

Index numbers: Definition, Criteria for a good index number, different types of index numbers. Construction of index numbers of prices and quantities,

consumer price index number. Uses and limitations of index numbers. Consumer price index number: construction of consumer price index numbers. Applications of consumer price index numbers.

Time Series Analysis: 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, method of semi-averages and method of least squares(linear).Measurement of seasonal variations by method of ratio to trend.

Unit2:VitalStatistics 15 Hours

Sources of demographic data, errors in data. Measurement of mortality: crude deathrate, specific death rates, and standardized death rates, infant mortality rate, maternalmortality rate, neonatal mortality rates, merits and demerits and comparisons of various mortality rates. Measurement of Fertility and Reproduction: Fecundity, fertility, measurement offertility, crude birth rate, general fertility rate, age specific fertility rate and total fertility rates, merits and demerits of each measure of fertility, comparative study of these measures of fertility, Growth rates: Gross reproduction rate and Net reproduction rates.

Unit3:SamplingMethods 12Hours

Population and Sample. Need for sampling, Complete Enumeration versus Sample Surveys, Merits and Demerits, Non-Probability and Probability Sampling, Need and illustrations. Use of random numbers, principal steps in sample survey. Requisites of a good questionnaire. Pilot surveys, Sampling and non – sampling errors, Description of simple random sampling with and without replacement procedures, Merits and demerits of Simple random sampling. Need for stratification,stratifying factors,Merits and demerits of stratified random sampling. Systematic random sampling procedure of obtaining sample, Merits and demerits ofsystematic random sampling.

OPEN ELECTIVE-: STOE102: STATISTICAL METHODS AND APPLICATIONS

Course Title: Statistical Methods and Applications	Course Credits:3
Total Contact Hours: 42	Duration of ESA: 2 hours
Formative Assessment Marks:40	Summative Assessment Marks:60

Number ofTheory Credits	Number of lecture hours/semester	Number ofpractical Credits	Number of practicalhours/ semester
03	**42**	**-**	**-**

Course Objectives

- This is an open elective course for other than statistics students.
- The students will learn the elements of descriptive statistics, probability,statistical methods such as tests of hypotheses, correlation and regression.

Course Outcomes

Students will be able to

CO-1.Acquire knowledge of statistical methods.

CO-2. Identify types of data and visualization, analysis andinterpretation.

CO-3.Learn elementary probability and probability models.CO-4.Learnto apply test procedures for given dataset.

Pedagogy

The course is taught using traditional chalk and talk method using problem solving through examples and exercises.

Students are encouraged to use resources available on open sources.

Course Contents

Unit1: Introduction 10Hours

Definition and scope of Statistics. Data: quantitative and qualitative, attributes, variables, scales of measurement: nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives. Concepts of population and sample. Sampling from finite population

.Simple random sampling, Stratified and systematic random sampling procedures (definitions andmethods only). Concepts of sampling and non-sampling errors.

Unit2: Univariate and Bivariate Data Analysis 10Hours

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range,quartile deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis. Bivariate data, scatter diagram, Correlation, Karl-Pearson'scorrelation coefficient, Rank correlation. Simple linear regression, principle of least squares.

Unit3:Probability and Distributions 12 Hours

Probability :Random experiment,trial, sample space, events- mutually exclusive and exhaustiveevents.Classical, statistical and axiomatic definitions of probability, addition and multiplication theorems, Bayes theorem(only statements).Discrete and continuous random variables, probability mass and density functions, distribution functions, expectation of a random variable.Standard univariate distributions: Binomial, Poisson and Normal distributions(Elementary properties and applications only).

Unit4: Sampling Distributions and Testing of Hypothesis 10 Hours

Distribution of sample mean from a normal population, Chi-square, t and F distributions (No derivations)and their applications. Statistical Hypothesis : null and alternative hypothesis, Simple and composite hypothesis. Type I and Type II errors, level of significance, criticalregion,

P- value and its interpretation.Test for single mean, Test for single proportion and equality of proportionsequality of two means, single variance and equality of two variances for normal populations.

References

1. Daniel,W.W.(2007 Biostatistics-A Foundation for Analysis in the Health Sciences,Wiley
2. T.W.Anderson and Jeremy D.Finn(1996).The New Statistical Analysis of Data,Springer.
3. Mukhyopadyaya P(1999).Applied Statistics,New Central book Agency,Calcutta.
4. Ross,S.M.(2014)Introduction to Probability and Statistics For Engineers and Scientists.
5. Cochran,WG (1984):Sampling Techniques,Wiley Eastern,New Delhi.
6. S.C Gupta, V.K Kapoor: Fundamentals of Mathematical Statistics

Course Content of Semester–II

STCT151: *Probability and Distributions-I*

Course Title: Probability and Distributions-I	Course Credits:4
Total Contact Hours: 56	Duration of ESA:2hours
Formative Assessment Marks:40	Summative Assessment Marks:60

Number of TheoryCredits	Number of Lecture hours/semester	Number of practicalCredits	Number of Practical hours/semester
04	**56**	**02**	**52**

Content of Theory Paper 2	**56 hrs**
Unit–1 :Probability	**14hrs**
Probability: Introduction, random experiments, sample space, events and algebra of events.Definitions of Probability– classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.	
Unit–2:Random variables, Mathematical Expectation and Generating Functions	**14hrs**
Random variables:discrete and continuous random variables ,p.m.f. ,p.d.f. and c.d.f., Illustrations, univariate transformations with illustrations. Mathematical Expectation and Generating Functions: Expectation of single random variables and its properties. Moments and cumulants, moment generating function, cumulant generating function, probability generating functions(p.g.f.).Probability inequalities(Markov's and Chebychev's).	
Unit–3:Standard Discrete and Continuous distributions	**18hrs**
Standard discrete probability distributions: Bernoulli, Binomial, Poisson, Geometric-Mean, Variance, Recurrence relation for the central moments, limiting properties, Relationship between distributions, Fitting of Binomial an Poisson distributions. Standard continuous probability distributions: Uniform, Gamma, Normal-Mean, Variance, Properties, Fitting of Normal distributions. Applications of discrete andcontinuous distributions.	
Unit –4:Data Analysis Using R	**12hrs**

Introduction to R: R as a calculator, statistical software and a programming language, R preliminaries, getting help, data inputting methods(direct and importing from other spread sheet applications like Excel), data accessing, and indexing, packages, Graphics in R, built in functions, saving, storing and retrieving work. Descriptive statistics:, measures of central tendency (mean, median and mode), partition values, measures of dispersion (range, standard deviation, mean deviation and inter quartile range), summaries of a numerical data, skewness and kurtosis.

Creating a vector using c (), reg() and Colon operator-Functions to summarize a vector sum mean, sd, median etc. Extracting a subset from the vector (by index, by property) Introduction to plotting, plot(), lines(), Abline(), Barplot, Pie chart and Histogram-Box plot, Scatter Plot and fitting simple linear regression.

Probability Distributions: R as a set of statistical tables- cumulative distribution, probability

density function, quantile function, and simulate from the distribution, plotting probabilitycurves for standard distributions.

Self Study-

- Covariance, Correlation coefficient for Bivariate Probability distributions
- Plotting graphs of Various Probability Distribution using R
- Discrete uniform Distribution
- Negative Binomial Distribution
- Hypergeometric Distriution
- gg plot package in R

References

1. Dudewitz.E.J.and Mishra.S.N.(1998).Modern Mathematical Statistics. JohnWiley.
2. Goon A.M.,Gupta M.K.,Das Gupta.B.(1991),Fundamentals of Statistics, Vol.I, World Press, Calcutta.
3. Hogg R,V.,Mckean J.W, and Craig,A.T(2019).Introduction to mathematical Statistics,8th Edition,Pearson Education, New Delhi.
4. Hogg,R.V.,Tanis,E.A .and RaoJ.M.(2009).Probability and StatisticalInference, Seventh Edition, Pearson Education, New Delhi.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007). Introduction to the Theoryof

Statistics,3rd Edition. (Reprint), Tata McGraw-Hill Pub.Co. Ltd.

6. Ross,S.(2002), A First Course in Probability, Prentice Hall.

7. Sudha G. Purohit, Sharad D. Gore, Shailaja R Deshmukh,(2009). Statistics Using R, Narosa Publishing House.

8. Emmanuel Paradis(2005). R for Beginners (available at https://cran.rproject.org/doc/contrib/Paradisrdebuts_en.pdf)

Pedagogy

- The course is taught using traditional chalk and talk methodusing problem solving through examples and exercises.
- Students are encouraged to use resources available on open sources.

STCP151: Practical 2 **4 Hrs Per week**

List of Experiments

(Computing all the practicals manually and using Excel/R)

1. Two exercise on Descriptive statistics (Presentations, Summarizations, correlations, regression and Graphs using R)
2. Computing probability: using addition and multiplication theorems.
3. Conditional probability and Bayes' theorem.
4. Problems on pmf, expectation, variance, quantiles, skewness, kurtosis (Discrete Case).
5. Problems on pdf, expectation, variance, quantiles, skewness, kurtosis (Continuous case).
6. Problems on discrete probability distributions(Binomial and Poisson)
7. Problems on Normal probability distributions
8. Computation of Moments
9. Fitting of distributions Binomial, Poisson, Normal distributions.
10. Generation of random samples. (Binomial, Poisson, Normal distributions)

STOE152: Business Statistics

Course Title: Business Statistics	Course Credits:3
Total Contact Hours: 42	Duration of ESA: 2 hours
Formative Assessment Marks:40	Summative Assessment Marks:60

Number of TheoryCredits	Number of lecture hours/semester	Number of practical Credits	Number of practical hours/semester
03	**42**		

Course Objectives

- Provide an introduction to basics of statistics within a financial context.
- To enable students to use statistical techniques for analysis and interpretation of businessdata.

Course Outcomes (COs)

Upon the completion of this course students should be able to:

CO1.Frame and formulate management decision problems.

CO2. Understand the basic concepts underlying quantitative analysis.

CO3.Use sound judgment in the applications of quantitative methods to management decisions.

Pedagogy

The course is taught using traditional chalk and talk method using problem solving through examples and exercises.Students are encouraged to use resources available on open sources.

Course Contents

Unit1: Statistical Data and Descriptive Statistics 12 Hours

Nature and Classification of data: univariate, bivariate and multivariate data; time-seriesand cross-sectional data. Measures of Central Tendency:

mathematical averages including arithmetic mean geometric mean and harmonic mean, properties and applications. Positional Averages Mode and Median (and other partition values including quartiles, deciles and percentiles).Measures of Variation: absolute and relative. Range, quartile deviation, mean deviation, standard deviation, and their coefficients, Properties of standard deviation/ variance Skewness: Meaning, Measurement using Karl Pearson and Bowley's measures ;Concept of Kurtosis.

Unit2: Simple Correlation and Regression Analysis 10 Hours

Correlation Analysis: Meaning of Correlation: simple, multiple and partial; Correlation andCausation, Scatter diagram, Pearson's co-efficient of correlation; calculation and properties(Proof not required). Correlation and Probable error; rank correlation.

Regression Analysis: Principle of least squares and simple linear regression (SLR).Fitting of Simple Linear Regression and interpretation. Properties of regression coefficients; Standard Error of Estimate and its use in interpreting the results.

Unit3: Index Numbers and Time Series 20 Hours

Definition, Problems involved in the construction of index numbers, methods of constructing index numbers of prices and quantities, simple aggregate and price relatives method, weighted aggregate and weighted average of relatives method, important types of weighted index numbers: Laspeyre's, Paasche's, Bowley's, Marshall- Edgeworth, Fisher's, method of obtaining price and quantity index numbers, tests consistency of index numbers, time reversal test and factor reversal test for index numbers, Uses and limitations of index numbers. Consumer price index number: Problems involved in the construction of cost of living index number, advantages and disadvantages, Aggregative expenditure method and Family budget method for the construction of consumer price index numbers. Applications of Cost of Living Index numbers.

Introduction, definition and components of Time series, illustrations, Additive, Multiplicative and mixed models, analysis of time series, methods of studying time series: Secular trend, method of moving averages, least squares method–

linear, quadratic, exponential trend fittings to the data. Seasonal variation- definition, illustrations, measurements, simple average method, ratio to moving average method, Cyclical variation definition, distinction from seasonal variation, Irregular variation- definition, illustrations.

References

1. Levin, Richard, David S. Rubin, Sanjay Rastogi, and H M Siddiqui. Statisticsfor Management.7th ed., Pearson Education.
2. David M. Levine, Mark L. Berenson, Timothy C. Krehbiel, P.K. Viswanathan, Business Statistics :A First Course, Pearson Education.
3. Siegel Andrew F. Practical Business Statistics. Mc Graw Hill Education.
4. Gupta, S.P., and Archana Agarwal. Business Statistics, Sultan Chand and Sons, New Delhi.
5. Vohra N.D., Business Statistics, McGraw Hill Education.
6. Murray R Spiegel, LarryJ. Stephens, Narinder Kumar. Statistics (Schaum'sOutlineSeries),Mc-Graw Hill Education.
7. Gupta, S.C. Fundamentals of Statistics. Himalaya Publishing House.

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STOE-152.Biostatistics

Course Title: Biostatistics	CourseCredits:3
TotalContactHours:42	Duration of ESA:2 hours
FormativeAssessmentMarks:40	SummativeAssessmentMarks:60

Course Objectives

1. To understand the data types, types of variables and scales ofmeasurement.
2. To understand different descriptive statistics in data analysis. Present data summary intabular form and graphs.
3. To understand importance of random sampling and sampling technique.
4. To understand the concept of uncertainty in biological sciences and basics of probabilityand probability distributions.
5. To understand the concept of testing of hypothesis and errors in decision making
6. To know about bivariate and multivariate data, Measures of relationship: correlation andregression.

Course Learning Outcomes

After studying the course, the student will be able to apply statistical tools and techniques in data analysis of biological sciences.

Pedagogy

- The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
- Students are encouraged to use resources available on open sources.

Course Contents

Unit1: Introduction to Bio-Statistics & Descriptive Statistics 15hours

Statistics and Health Science, Role of Biostatistics in Life Sciences. Definition and scope of Statistics. Scales of Measurement: nominal, ordinal, interval and ratio. Collection, classification and tabulation of data,

Measures of Central Tendency: Arithmetic mean, Median and Mode-definition, properties, merits and limitations.

Measures of Dispersion: Range, Standard deviation and Coefficient of Variation. Correlation and Regression Analysis: Bivariate Data,Scatter Diagram, definition of correlation, types of correlation,

Karl-Pearson's coefficient of correlation and its properties, Spearman's Rank Correlation coefficient. Regression-Simple linear regression, fitting of regression equations by method of Least Squares, regression coefficients and their properties and interpretation.

Unit2: Probability and Probability Distributions 12Hours

Probability: Random experiment, sample space, events-mutually exclusive and exhaustive events. Classical, statistical and axiomatic definitions of probability, addition and multiplication theorems, Bayes' theorem(only statements) and its application. Sensitivity, Specificity, positive predictive value, negative predictive value, odds ratio.

Discrete and continuous random variables, probability mass and density functions, distribution functions, expectation of a random variable. Standard univariate distributions: Bernoulli, Binomial, Poisson and Normal distributions(Elementary properties and applications only).

Unit3: Sampling Distributions and Statistical Inference 15hours

Concepts of random sample and statistic, distribution of sample mean from a normal population, Chi-square, t and F distributions (No derivations) and their applications. Estimation of population mean, population standard deviation and population proportion from the sample counterparts. Statistical hypothesis: null and alternative hypothesis, simple and composite hypothesis. Type I and Type II errors, size, level of significance,power test, critical region, P-value and its interpretation. Test for single mean, equality of two means, s ingle variance, equality of two variances for normal Populations, Test for proportions. ANOVA and Nonparametric Tests.

Self study component : construction of frequency table for grouped and ungrouped data, graphical re presentation of data by histogram, polygon, ogive curves and Pie diagram.

References

1. Dutta, N.K.(2004),Fundamentals of Biostatistics, Kanishka Publishers.
2. Gurumani N.(2005),An Introduction to Biostatistics, MJP Publishers.
3. Daniel,W.W.(2007),Biostatistics-AFoundationforAnalysisintheHealthSciences,Wiley
4. Rao,K.V.(2007),Biostatistics A Manual of Statistical Methods for use in Health Nutrition and Anthropology
5. Pagano, M .and Gauvreau, K.(2007), Principles of Biostatistics.
6. Rosner Bernard (2010), FundamentalsofBiostatistics,6thEdition,Duxbury.

II B.Sc. StatisticsCourse Content of Semester– III

STCT 201 -Calculus and Probability Distributions

Type of Course	Formative Assessment / IA	Summative Assessment
Theory	**40**	**60**
Practical	**25**	**25(20+5(Practical record))**

Course Title: **Calculus and Probability Distributions**	
Total Contact Hours: 56	Course Credits:04
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Summative Assessment Marks: 60	

Number of Theory Credits	Number of lecture hours/semester	Number of practical Credits	Number of practical hours/semester
4	**56**	**2**	**52**

Course Objectives

To enable the students to

1. Know the concept of continuity, differentiability, integration of one and more variables.
2. Define and describe properties of Joint, Marginal and conditional distributions of variables and some key concepts of probability theory.
3. Understand different discrete, continuous and sampling distributions, properties and their applications.
4. Generate random variables from various distributions using R-code.

Course Outcomes

After completion of this course the students will be able to

1. Judge continuity of a function, find integrations and solve problems of differentiability.
2. Solve problems of various analytical environments using different distributions and their properties.
3. Find sampling distributions of functions of random variables and explore their applications.

STCT 201- Theory Paper 3 : Calculus and Probability Distributions

Content of Theory Paper 3	56 Hrs
UNIT 1: Calculus of one and more variables	**10 Hrs**
Review of calculus of one variable: continuity, differentiability Taylor series expansion. Functions of several variables: partial derivatives Applications of partial differentiation, Jacobian., integration by parts,. Multiple integrals and evaluation of multiple integrals by repeated integration, Sequences and Series of real numbers. convergence of sequences and series, tests for convergence of series.(Only results and applications). Gamma integral, Beta integral, Maxima and Minima functions	
UNIT 2: Distribution of Random Variables (Two-dimensional)	**13 Hrs**
Two dimensional random variables: Joint distribution, Marginal distribution and Conditional distributions of random variables, Independence of random variables, theorems on expectation, conditional expectation, covariance, correlation and moments. Distribution of functions of random variables using m.g.f. and distribution function. Transformation of variable technique (two variables). Chebyshev's inequality- proof and its use in approximating probabilities; Convergence in law and convergence in probability. Statements of Weak Law of Large Numbers; and Central Limit theorems – De-Moivre. (Some simple examples)	
UNIT 3: Probability Distributions-II	**18 Hrs**

Discrete distributions: Rectangular, Negative Binomial, Hypergeometric, Multinomial- definition through probability mass function, mean, variance, moments, p.g.f., m.g.f., other properties and applications. Continuous distributions: Exponential (single and double parameters), Beta (type 1 and type 2), Cauchy, Weibull– definition through probability density function, mean, variance, moments, m.g.f., other properties and applications. Bivariate normal distribution- definition through probability density function, marginal and conditional distribution.	
UNIT 4: Sampling Distributions and Simulation	**15 Hrs**
Definitions of random sample, parameter and statistic, sampling distribution of sample mean, standard error of sample mean, sampling distribution of sample variance, standard error of sample variance. Exact sampling distributions: Chi square distribution- mean, variance, mode, additive property. Student's t-distribution- mean, variance and limiting form of t distribution. Snedecor's F-distribution: mean, variance and mode. Distribution of 1/F. Relationship between t, F and χ^2 distributions. Assuming the independence of sample mean $\bar{x}$ and sample variance S^2 when sampling from normal population derive the distribution of $\frac{\bar{x}}{\sqrt{\frac{S^2}{n}}}$. Introduction to simulation. Generation of random observations from Uniform, Exponential, Monte Carlo Simulation Technique	

Text Books:

1. Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, SultanChand and Co. 12th Edition.

2.Shanthi Narayana (2000), Integral Calculus, S. Chand & Co. Ltd.

References

1. Andre I Khuri (2003). Advanced Calculus with Applications in Statistics, Second Edition, John Wiley & Sons.
2. Ghorpade, S. R. and Limaye, B. V. (2006). A Course in Calculus and Real Analysis, Springer
3. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7th Edition.
4. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical Inference, 10th Edition, Pearson Education, New Delhi.
5. Jay Kerns, G. (2010). Introduction to Probability and Statistics using R. 1st Edition,

Springer.
6. Rohatgi, V.K. and A.K. Md. Ehsanes Saleh. (2002). An Introduction to Probability Theory and Mathematical Statistics, New York, John Wiley.
7. Ross, S. M. (2014). Introduction to Probability Models. 11th Edition, Elsevier science.
8. Ross, S. M. (2012). Simulation. Academic Press.
9. Shanti Narayana (2000). Differential Calculus, S. Chand & Co. Ltd.
10. Verzani, J. (2002). Simple R - Using R for Introductory Statistics.

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

STCP 201- Contents of Practical 3

Note: The first practical assignment is on R-programming. Practical assignments 2 to 10 have to be first solved manually (using scientific calculators) and executed using R-programming.

1. Demonstration of R functions for calculus, distribution of random variables, probability distributions, sampling distribution simulation.
2. Numerical differentiation and integration-I
3. Numerical differentiation and integration-II
4. Bivariate Probability Distributions - Marginal and Conditional distributions,
5. Bivariate Probability Distributions - Conditional Mean, Conditional Variance, Correlation.
6. Applications of Chebyshev's inequality (For standard distributions such as Normal, Exponential, Gamma).
7. Applications of discrete probability distributions - Negative – Binomial, Hyper geometric and discrete uniform, multinomial distributions.
8. Applications of continuous probability distributions - Exponential, Gamma, Cauchy, Weibull distributions.
9. Fitting of discrete and continuous distributions.
10. Generating random sample from continuous distributions.

STOE 201- Population Studies (STOE 251)

Course Title: Population Studies	CourseCredits:3
TotalContactHours:42	Duration of ESA:2 hours
FormativeAssessmentMarks:40	SummativeAssessmentMarks:60

Number of TheoryCredits	Number of lecture hours/semester	Number of practical Credits	Number of practical hours/semester
03	**42**		

Course Objectives

1. To enable the students to identify appropriate sources of data, perform basic demographic analysis using various techniques and ensure their comparability across populations.
2. To acquire knowledge about the construction of life table and its applications in demographic analysis.

Course Outcomes (CO)

Upon successful completion of this course the student will be able to

CO1. Study the concepts of Vital Statistics, sources of data, different measures of Fertility, Mortality and migration.

CO2. Understand the Growth rates- GRR and NRR and their interpretations.

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

Contents

UNIT-1: Introduction and Sources of Population Data **14 hours**

History, definition, nature and scope of population Studies. Sources of population data – salient features of Census, Civil Registration System, National Sample Surveys, Demographic Surveys, relative merits and demerits of these sources. Coverage and content errors. Use of balancing equations,

UNIT-2 : Fertility, Mortality **14 hours**

Basic concepts and terms used in the study of fertility. Measures of fertility- Crude Birth Rate (CBR), General Fertility Rate (GFR), Age Specific Fertility Rate (ASFR), Total Fertility Rate (TFR), Birth order statistics, Child Women ratio. Measures of reproduction- Gross Reproduction Rate (GRR)and Net Reproduction rate(NRR). Measurement of population growth rate- simple growth rate and compound growth rate. Basic concepts and terms used in the study of mortality. Measures of mortality- Crude Death Rate (CDR), Age Specific Death Rate (ASDR), Direct and Indirect Standardized Death rates, Infant Mortality Rate (IMR), Under-five mortality Rate, Neo-natal mortality rate, Post-natal mortality rate; Maternal Mortality Rate (MMR).

UNIT-3: Life tables and Population change **14 hours**

Life tables: Components of a life table, force of mortality and expectation of life table, types of life tables. Uses of life tables.

Basic concepts and definition of population change, migration. Types of migration- internal and international, factors affecting migration. Rates and ratios of Migration-Indirect measures of net-internal migration, national growth rate method, residual method, push-pull factors Population estimates and projections.

References

1. Barclay, G, W(1968). Techniques of Population Analysis, John Wiley and Sons, Incs. New York
2. Keyfitz, H (1968). Introduction to the Mathematics of Population. Addison-Wesley Publishing Co.
3. Pathak, K.B and Ram, F (1991).Techniques of Demographic Analysis, Himalaya Publishing House.
4. Ramakumar. R (1986). Technical Demography, Wiley Eastern Ltd.
5. Srinivasan. K (1998). Basic Demographic Techniques and Applications, Sage Publication, New Delhi.
6. Wunsch G.J. & M.G. Tarmota(1978). Introduction to Demographic Analysis, Plenum Press, N.Y.

STOE202- Basics of Operations Research

Course Title: Basics of Operations Research	CourseCredits:3
TotalContactHours:42	Duration of ESA:2 hours
FormativeAssessmentMarks:40	SummativeAssessmentMarks:60

Number of TheoryCredits	Number of lecture hours/semester	Number of practical Credits	Number of practical hours/semester
03	**42**		

Course Objectives

1. Students get knowledge about the scope and application of Operations Research(OR)in business and industry.
2. Exposes the students to various OR tools and models.
3. To get knowledge about various decision making through OR models.

Course Outcomes

Students will be able to

CO1- Generate mathematical models of business environment.CO2-

Analyze the business situations.

CO3-Use different solution procedures through OR models.

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving throughexamples and exercises.
2. Students are encouraged to use resources available on open sources.

Contents

Unit-1: Introduction to Operations Research(OR) 14 hours

Origin and growth of OR, importance of OR in managerial decision making, scope andapplications of OR, models and modeling in OR. Linear programming problems(LPP):Formulation of the problem, feasible & infeasible, basic feasible solution, optimal, unbounded andmultiple optimal solutions of LPP, solution by graphical method. Slack, Surplus and Artificialvariables. Duality in LPP, Importance of Duality Concepts, Formulation of Dual Problem,Economic Interpretation of Duality.

Unit-2: Allocation Problems 14 hours

Transportation problems: Formulation, methods of finding initial solution (North West Corner Rule, Least Cost Method and Vogel's Approximation Method), unbalanced transportation problems, maximization transportation problem.

Assignment problems: Formulation, methods of solution, Hungarian method, multiple optimal solutions, unbalanced problems, maximization problems.

Unit-3: Decision theory 14 hours

Game theory: Basic concepts. Two – Person Zero Sum Game. Pure and Mixed Strategies. Maximin – Minimax principle, Games with and without saddle points. Principle of dominance.

Concepts of decision making, decision making environments, Decision making under uncertainty - Decision making under risk, decision tree analysis. Case discussion.

Concepts of network analysis, project network models, Critical Path Method, PERT.

References

1. Hillier, F S, et al. Introduction to Operations Research (9/e). Tata McGraw Hill, 2011.
2. Ravindran, A and Don T Phillips. Operations Research: Principles and Practice. JohnWiley & Sons, 1987.
3. Sharma, J K. Operations Research: Theory and Applications (5/e). New Delhi: Laxmi Publications, 2013.
4. Taha, Hamdy A. Operations Research: An Introduction (9/e). Prentice Hall, 2010.
5. Vohra, N D. Quantitative Techniques for Management. Tata McGraw Hill Education,2015.
6. Kanti Swarup, Gupta, P.K. and Man Mohan: Operations Research, Sultan Chand & Sons,New Delhi.
7. Kapoor, V.K: Operations Research, Sultan Chand & Sons, New Delhi.
8. Kapoor, V.K.: Operations Research Problems & Solutions, Sultan Chand & Sons, NewDelhi.

II B.Sc. StatisticsCourse Content of Semester– IV

STCT 251: Statistical Inference-I

Course Title: **Statistical Inference-I**	
Total Contact Hours: 56	Course Credits:04
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Summative Assessment Marks: 60	

Number of Theory Credits	**Number of lecture hours/semester**	**Number of practical Credits**	**Number of practical hours/semester**
4	**56**	**2**	**52**

Course Objectives

To enable the students to understand the concepts of

1. Families of distributions, order statistics and their distributions.
2. Estimation, criteria for estimators, methods of estimation, confidence interval.
3. Testing of Hypotheses and its theoretical aspects, large and small sample tests.

Course Outcomes

After completion of the course, the students will be able to

1. Carryout statistical analysis by identifying families of distributions and the use of orderstatistics.
2. To find estimators using different methods of estimation and compare estimators.
3. To carryout statistical inference using different tests of hypotheses under different scenarios.
4. Generate random variables and use these generated random variable for illustration ofconcepts studied in this course.

STCT 251-Theory Paper 4 - Statistical Inference-I

Content of Theory Paper 4	56 Hrs
UNIT 1: Point Estimation-I	**16 Hrs**
Families of distributions- location and scale families. Single parameter exponential family. Concept of order statistics, Distribution of maximum and minimum order statistics (with proof) and r^{th} order statistic (without proof). Concepts of estimator and estimate. Criteria for estimators: Unbiasedness, Consistency. Invariance property of consistent estimators. Efficiency and relative efficiency. Mean squared error as a criterion for comparing estimators. Sufficient statistics. Statement of Neyman-Factorization theorem.	
UNIT 2: Point Estimation-II	**12 Hrs**
Fisher information function. Statement of Cramer–Rao inequality and its applications. Minimum Variance Unbiased Estimator and Minimum Variance Bound Estimator. Maximum likelihood and method of moment estimation; Properties of MLE and moment estimators and examples. Method of Scoring	
UNIT 3: Testing of Hypotheses	**18 Hrs**
Statistical hypotheses - null and alternative, Simple and composite hypotheses. Type-I and Type-II errors, test functions. Randomized and non-randomized tests. Size, level of significance, Power function, power of tests. Critical region, p- value and its interpretation. Most Powerful (MP) and UMP test(Statement only). Statement of Neyman-Pearson Lemma and its applications. Likelihood ratio tests. Large and small samples tests of significance. Tests for single mean, equality of two means, singlevariance and equality of two variances for normal populations. Tests for proportions.	
UNIT 4: Interval Estimation	**10 Hrs**
Confidence interval, confidence coefficient, shortest confidence interval. Methods of constructing confidence intervals using pivotal quantities. Construction of confidence intervals for mean, difference of two means, variance and ratio of variances, proportions, difference of two proportions and correlation coefficient.	

Text Books:

1. **1.** Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, SultanChand and Co. 12^{th} Edition.
2. Rohatgi, V.K. and A.K. Md. Ehsanes Saleh. (2002). An Introduction to Probability Theoryand Mathematical Statistics, New York, John Wiley.
3.

References

4. Chihara, L. and Hesterberg, T. (2011) Mathematical Statistics with Resampling and R. Wiley.

5. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7th Edition.
6. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical Inference, 10th Edition, Pearson Education, New Delhi.
7. Johnson, R.A. and Bhattacharyya, G.K. (2006), Statistics: Principles and methods. 5th Edition, John Wiley & Sons, New York.
8. Kale, B.K. (1999). A First Course on Parametric Inference, New Delhi, Narosa Publishing House.
9. Kendall, M.G., et. al., (1996). An Introduction to the Theory of Statistics, Universal Book Stall.
10. Ross, S.M. (2014), Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Academic Press.

STCP 251- Contents of Practical 4

Note: The first practical assignment is on R-programming and R packages. Practical assignments 2 to 10 have to be first solved manually (using scientific calculators) and executed using R- programming.

1. Demonstration of R-functions for estimation and testing of hypotheses.
2. Computing maximum likelihood estimates.
3. Computing moment estimates.
4. Interval estimation: Construction of confidence interval (large samples)
5. Interval estimation: Construction of confidence interval (small samples)
6. Evaluation of Probabilities of Type – I and Type – II errors and power of tests.
7. Small sample tests: Tests for mean, equality of means under normality when variance is (i)known (ii) unknown, P-values.
8. Large sample tests: single proportion and equality of two proportions, variance and equalityof two variances under normality. P-values for the above tests.
9. Large sample tests: Tests for mean, equality of means when variance is (i) known (ii) unknown, under normality.
10. Test for variance and equality of two variances under normality. P- values for the above tests.

STOE 252-Survival Models

Course Title: Survival Models	CourseCredits:3
TotalContactHours:42	Duration of ESA:2 hours
FormativeAssessmentMarks:40	SummativeAssessmentMarks:60

Number of TheoryCredits	Number of lecture hours/semester	Number of practical Credits	Number of practical hours/semester
03	**42**		

Course Objectives

1. Enable the students to construct and interpret life tables.
2. To understand the concepts of Survival analysis.
3. To study the design of clinical trials and their analysis.

Course Outcomes:

By the end of this course, the student should be able to:

CO1.Explain Life Tables, types of life tables, its functions, construction.

CO2. Describe multiple decrement life tables and their construction.

CO3. Know survival models, concepts of survival analysis, notion of ageing.

CO4. Explain key concepts in the design of clinical trials, phases, types, clinical trial protocol, analysis.

Content

Unit-1: Life Tables **14 hours**

Basic definition and notations, Types of life tables, inter – relationships between life table functions, Properties of life table functions. Construction of life tables using Reed – merrel and Greville's Method. Competing causes of failure/death, Multiple decrement life tables and their construction (with examples).

Unit-2: Survival Concepts **14 hours**

Life distributions, survival functions, failure rate, Integrated hazard function, residual life time, meanresidual life time. Notion of aging: IFR, IFRA, DMRL, NBU, NBUE classes of life distributions andtheir dual classes. Common Life Distributions: binomial, Poisson, exponential, Weibull, gamma, Pareto and log-normal distributions.

Unit-3: Clinical Trials **14 hours**

Basics of Clinical Trials: Who can be in clinical trials? need clinical trials, Brief History of Clinical Trials, Common Terms in clinical Trials: Clinical Research, Healthy Volunteer, Inclusion/Exclusion Criteria, Informed Consent, Patient Volunteer, Phases of Clinical Trials, Placebo, Protocol, Principal Investigator, Randomization, Single- or Double-Blind, Studies, Types of Clinical Trials. - Diagnostic trials, Natural history studies, Prevention trials, Quality of life trials, Screening trials, Treatment trials, therapeutic trials and prophylactic trials. Observational studies – Cross sectional studies, prospective studies, retrospective studies, randomized control studies. Clinical Trial Protocol and its components. Type of analyses: ITT, mITT and PP. Odds ratio, Relative risk, Sensitivity, specificity, false negative and false positive rates. Receiver operating characteristic(ROC) curve.

References

1. Deshpande, J V and Purohit, Sudha (2005). Life Time Data: Statistical Models and Methods. World Scientific.
2. Friedman, Furberg, and DeMets. (2010). Fundamentals of Clinical Trials (4th Edition). Springer, Free text available online at http://dx.doi.org/10.1007/978-1-4419-1586-3
3. Lawrence MF, Curt DF, David LD (2010), Fundamentals of clinical trials.
4. R. Ramkumar (1986), Technical Demography, Wiley Eastern, New Delhi.
   Shryock, Henry S, Jacob S, Siegel and Associates (1964). Methods and materials of demography (condensed edition), Academic press, London

STOE 253- Quantitative Analysis Techniques

Course Title: Survival Models	CourseCredits:3
TotalContactHours:42	Duration of ESA:2 hours
FormativeAssessmentMarks:40	SummativeAssessmentMarks:60

Number of TheoryCredits	Number of lecture hours/semester	Number of practical Credits	Number of practical hours/semester
03	**42**		

Course Objectives

To enable the students to acquire the knowledge about

- Data analysis using descriptive statistics.
- Study of relationship between the two variables
- To understand the concept of Probability and its applications

Course Outcomes

Students will be able to

CO1. Compute various measures of descriptive statistics

CO2. Carryout correlation and regression analysis.

CO3. Students are able to understand the concept of probability and its applications

Pedagogy

The course is taught using traditional chalk and talk method using problem solving through examples and exercises. Students are encouraged to use resources available on open sources.

Course Content

UNIT- 1: Descriptive Statistics **14 hours**

Measures of central value: mean, median, mode, geometric mean and harmonic Mean,

combined arithmetic mean(definition, computation, and relative merits And demerits)

Measures of dispersion: range, mean deviation, standard deviation, coefficient of Variation, variance- combined standard deviation(definition, computation and relative merits and demerits)

UNIT-2: Correlation and regression analysis **14 hours**

Correlation- Definition, Types - Simple, multiple, partial. Causation - Spurious, positive, negative, perfect and no correlation, explanation with examples. Importance of correlation analysis. Measurement of correlation- scatter diagram, Karl Pearson's coefficient of correlation, Properties of coefficient of correlation, interpretation. Spearman's coefficient of rank correlation – with and without ties, interpretation. Coefficient of determination and its interpretation.

Regression- Definition, regression lines/equations of X on Y and Y on X. Properties of regression coefficients and regression lines/equations. Principle of least squares and fitting of linear, quadratic and exponential curves. Uses of regression analysis. Comparison between correlation and regression.

UNIT-3: Introduction to classical probability

Definition and examples of sample space, event, mutually exclusive, exhaustive, equally likely events, complimentary event, null event, certain event. Classical definition of probability, definition of conditional probability, addition and multiplication theorem (statement only). Independent and dependent events – simple problems based on classical definition, conditional probability and addition and multiplication theorem.

References

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002). Fundamentals of Statistics, Vol. I, 8th Ed., The World Press, Kolkata.
2. Ross, S.M. (2014). Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Academic Press.
3. B.L.Agarwal(2009), *Basic Statistics*,New age international Pvt Ltd.
4. N.G. Das(2009),Statistical Methods, Tata McGraw Hill education Pvt Ltd.
5. K. Nagabhushan & others(2008), A classic text book of *statistics*, S.D.M Excellent publications.

III B.Sc. StatisticsCourse Content of Semester– V

STCT 301: Theory Paper 5: Matrix algebra and regression analysis (Theory)

Program Name	**B.Sc. in STATISTICS**	Semester	**V**
Course Title	**Matrix algebra and regression analysis (Theory)**		
Course Code:	**STCT 301**	No. of Credits	**04**
Contact hours	**60 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

CO1. Demonstrate and understanding of basic concepts of matrix algebra, including determinants, inverseand properties of various types of matrices.

CO2. Apply matrix algebra and linear algebra techniques to solve systems of linear equations, determine the rank of matrix, understanding quadratic forms and their applications in statistics, characteristicroots and vectors.

CO3. Understand the various aspects in simple and multiple linear regression models and their interpretation.

CO4. Apply regression analysis techniques to real world data sets.

Content of Theory Paper 5	**60 Hrs**
Unit 1: Algebra of matrices and determinants	15 Hrs
A review of matrix algebra, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, orthogonal matrices, singular and non-singular matrices and their properties. Trace of a matrix, unitary matrices. Adjoint and inverse of a matrix and related properties. Determinants ants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations.	
Unit 2: Linear Algebra	15 Hrs
Linear algebra: Use of determinants in solution to the system of linear equations, row reduction and echelon forms, the matrix equations AX=b, consistency of the linear system,	

solution sets of linear equations, inverse of a matrix. Vector space, subspace, linear dependence and independence of vectors. Basis and dimension, rank of a matrix row-rank, Column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton Theorem, Quadratic forms, nature of quadratic form and properties.	
Unit 3: Simple linear regression	15 Hrs
Simple linear regressions Model, assumptions, Least Squares estimation, estimation of intercepts & slope along with Standard error. Residual vector and proprieties, estimation of error variance. Test on regression coefficients, prediction, standard error of prediction, coefficient of determination. Diagnostic checks:- residual analysis for testing deviation from normality, homoscedasticity, outliers, randomness and lack-of-fit testing	
Unit 4:Multiple Linear Regression	15 Hrs
Multiple Linear Regression Model, Assumptions, Gauss- Markov Theorem (Without proof), Least square Estimation, variance-covariance of least squares estimators, estimation of error variance ,least square estimation with restriction on parameters, Tests on linear restriction on the parameters, testing the signification of each regressor and testing for overall signification of the model. Confidence intervals.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	Program Outcomes (POs)											
	1	2	3	4	5	6	7	8	9	10	11	12
Demonstrate and understanding of basic concepts of matrix algebra, including determinants, inverse and properties of various types of matrices.	x	x								x		
Apply matrix algebra and linear algebra techniques to solve systems of linear equations, determine the rank of matrix, understanding quadratic forms and their applications in statistics, characteristic roots and vectors.			x							x		
Develop and understanding of simple and multiple regression models, including the assumptions underlying these models, techniques for inference and hypothesis testing and method diagnostics checks and corrections.				x	x					x		

Apply regression analysis techniques to real word data sets				x	x							

Pedagogy:

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

Self study component :

1. Method of weighted least squares in simple linear regression
2. Inverse regression

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Internal Test 1	15
Internal Test 2	15
Assignment/Seminar (7 marks)+Attendance(3marks)	10
Total	**40 Marks**

STCP 301- Contents of Practical 5

Course Title	**Matrix algebra and Regression analysis (Practical)**		Practical Credits	**2**
Course Code	**STCP 301**		Contact Hours	**60 Hours**
Formative Assessment	**25 Marks**	Summative Assessment		**25 Marks**
Practical Content				

1. Calculation of determinant of higher order
2. Calculation of rank of a matrix
3. Calculation of equivalent canonical form by using elementary row and column operations
4. Calculation of inverse of matrices of higher order
5. Calculation of Eigen values and Eigen vectors
6. Solution of simultaneous equations
7. Simple Linear Regression
8. Multiple Regression-I
9. Multiple Regression -II.
10. Residual Analysis

Pedagogy: Practical assignments 1 to 10 have to be first solved manually (using scientific calculators) and executed using R-programming.

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Internal Test 1	10
Internal Test 2	10
Attendance	5
Total	**25 Marks**

References	
1	Ramachandra Rao, A. and Bhimasankaram, P. (2000). Linear Algebra.Hindustan Book Agency
2	Searle, S. R. (1982). Matrix Algebra Useful for Statistics, John Wiley, New York.
3	Kumaresan, S. (2000). Linear Algebra: A Geometric Approach, Prentice Hall
4	Shanthi narayan (1991):A text of Matrices, S. Chand & Company, New Delhi.
5	Devi prasad (2012): Elementary Linear algebra,2nd Ed. Norosa Publishing House.
6	Gilbert strang (2016) Linear Algebra and its Applications, 5th edition Cengage Learning.
7	Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003). Introduction to Linear Regression Analysis, Wiley.
8	Weisberg, S. (2005). Applied Liner Regression, Wiley.
9	Yan, X. and Su, X. G. (2009). Linear Regression Analysis: Theory & Computing, World Scientific.
10	Domodar .N Guajarati (2017):Basic Econometrics,5th Edition
11	Madanani GMK(2008):Introduction to econometrics Principles and applications, 8th Ed. Oxford and IBH Publishing company Pvt Ltd.

STCT 302: Theory Paper 6: Design and Analysis of Experiments (Theory)

Program Name	**B.Sc. in STATISTICS**	Semester	**V**
Course Title	**Design and Analysis of Experiments (Theory)**		
Course Code:	**STCT 302**	No. of Credits	**4**
Contact hours	**60 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

Course Outcomes (COs):

After the successful completion of the course, the student will be able to:

CO1. Identity fixed and random effect models and one-way and two-way classified data.

CO2.Choose appropriate designs (CRD, RBD, LSD) and missing plot techniques for a real life problem.

CO3. Identity appropriate factorial experiments for the real life problem.

CO4. Develop complete and partial confounding for factorial experiments.

Contents of Theory Paper 6	**60 Hrs**
UNIT 1: Concepts of Experiment: Design and Analysis.	20 Hrs
Experiments and their designs, principles of designs of experiments, experimental error and interpretation of data contrasts and analysis of variance, Fixed and random effects models, Analysis of One-way and two-way classified data without interaction. Multiple comparison tests: Tukey's method, Critical difference.	
UNIT 2: Experimental Designs.	20 Hrs
Completely randomized, randomized block and Latin square designs (CRD, RBD, LSD) – layout formation and the analysis using fixed effect models. Comparison of efficiencies of CRD, RBD and LSD. Estimation of one and two missing observations in RBD and LSD and analysis.	

UNIT 3: FACTORIAL EXPERIMENT	10 Hrs
Basic concepts – main and interaction effects, and orthogonal contrasts in 2^2 and 2^3 factorial experiments. Yates' method of computing factorial effects total. Analysis of $2^2$and 2^3factorial experiments in RBD.	
UNIT 4: CONFOUNDING	10 Hrs
Need for confounding. Types of confounding - Complete and partial, Confounding in a 2^3 - factorial experiment in RBD and its analysis.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	Program Outcomes (POs)											
	1	2	3	4	5	6	7	8	9	10	11	12
CO1.Learn about fixed, random, and mixed effect models and one-way and two-way classified data.	x	x		x		x			x	x		
CO2.Understand different designs (CRD, RBD, LSD) and missing plot techniques.	x	x				x			x	x		
CO3. Understand the different factorial experiments.	x	x				x			x	x		
CO4. Develop complete and partial confounding for factorial experiments.	x	x		x		x			x	x		

Pedagogy:

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.

2. Students are encouraged to use resources available on open sources.

Self study component :

1. Analysis of two-way classified data with interaction
2. Tukey's method of multiple comparison test

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Internal Test 1	15

Internal Test 2			15
Assignment/Seminar (7 marks)+Attendance(3marks)			10
Total			**40 Marks**
Course Title	**Design and analyses of experiments(Practical)**	Practical Credits	**2**
Course Code	**STCP 302**	Contact Hours	**60 Hours**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. ANOVA for one-way classified data.
2. ANOVA for two-way classified data.
3. Analysis of CRD.
4. Analysis of RBD.
5. Analysis of LSD.
6. Missing plot techniques in RBD and LSD.
7. Analysis of 2^2 factorial experiment using RBD layout.
8. Analysis of 2^3 factorial experiment using RBD layout.
9. Analysis of 2^3 factorial experiment using RBD layout (Complete confounding).
10. Analysis of 2^3 factorial experiment using RBD layout (Partial confounding).

Pedagogy: Practical assignments 1 to 10 have to be first solved manually (using scientific calculators) and executed using R-programming.

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Internal Test 1	10
Internal Test 2	10
Attendance	5
Total	**25 Marks**

References	
1	Goon, A. M., Gupta, M. K., Das Gupta, B.(1991). Fundamentals of Statistics, Vol-I, World Press, Calcutta.
2	Montgomery. D. C. (2014): Design and Analysis of Experiments, Wiley. New York.
3	Joshi. D. D. (1987): Linear Estimation and Design of Experiments, New Age International (P) Limited, New Delhi.
4	Cochran. G and G. M. Cox, G. M. (1992): Experimental Designs, John Wiley and Sons, New York.
5	Mukhopadhyay. P (2015): Applied Statistics, Books and Allied (P) Ltd., Kolkata.
6	Giri N C And Das M.N (1979) Design and Analysis of Experiments, Wiley Easter

III B.Sc. StatisticsCourse Content of Semester– VI

STCT 351: Theory Paper 7: Statistical Inference-II (Theory)

Program Name	**B.Sc. in STATISTICS**	Semester	**VI**
Course Title	**Statistical Inference-II (Theory)**		
Course Code:	**STCT 351**	No. of Credits	**04**
Contact hours	**60 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

Course Outcomes (COs): After the successful completion of the course, the student will be able to:

CO1. Basic aspects of decision theory and apply decision principles and Bayes and minimax decision rule.

CO2. Apply and interpret UMP test, MLR property and Likelihood

ratio tests.CO3. Explore about sequential inference.

CO4. Apply one sample and two sample nonparametric tests.

Contents of Theory Paper 7	**60 Hrs**
Unit-1: Statistical Decision Theory	15 Hrs
Basic elements of Statistical Decision Problem. Expected loss, decision rules (nonrandomized and randomized), decision principles (conditional Bayes, frequentist), inference as decision problem, Loss function, squared error loss, Bayes and minimax decision rule.	
Unit-2: Testing of Hypothesis-II	20 Hrs
Definition of UMP test, monotone likelihood ratio (MLR) property, Examples of distributions having MLR property, Construction of UMP test using MLR property. UMP test for single parameter exponential family of distributions. Likelihood ratio (LR)tests, LR test for normal, exponential.	
Unit -3: Sequential Inference	10 Hrs
Need for sequential analysis, Wald's SPRT, ASN, OC Functions, examples based on Bernoulli, Poisson, Normal and exponential distributions.	
Unit-4: Nonparametric tests	15 Hrs
Nonparametric and distribution-free tests, one sample problems: Sign test, Wilcoxon signed rank test, Kolmogorov-Smirnov test. Test of randomness using run test.	

General two sample problems: Wolfowitz runs test, Kolmogorov Smirnov two sample test (for sample of equal size), Median test, Wilcoxon-Mann-Whitney U-test. Several sample problems: Friedman's test, Kruskal Wallis test	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	Program Outcomes (POs)											
	1	2	3	4	5	6	7	8	9	10	11	12
CO1. Understand expected loss, decision rules, decision principles and Bayes and minimax decision rule.	x	x	x	x					x	x		
CO2. Learn about UMP test, MLR property and Likelihood ratio tests.	x	x	x	x					x	x		
CO3. Explore about sequential inference.	x	x	x	x					x	x		
CO4. Learn about one sample and two sample nonparametric tests.	x	x	x	x					x	x		

Pedagogy:

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.

2. Students are encouraged to use resources available on open sources.

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Internal Test 1	15
Internal Test 2	15
Assignment/Seminar (7 marks)+Attendance(3marks)	10
Total	**40 Marks**

STCP 351: Statistical Inference-II (Practicals)

Course Title	**Statistical Inference-II (Practicals)**	Practical Credits	**2**
Course Code	**STCP 351**	Contact Hours	**60 Hours**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. Problems on Bayes and minimax estimation.
2. UMP test based on sample from Bernoulli and Poisson distributions.
3. UMP test based on sample from Normal and exponential distributions.
4. Construction of SPRT for Bernoulli and Poisson distributions.
5. Construction of SPRT for Normal and Exponential distributions.
6. Evaluation of SPRT for Bernoulli and Poisson distributions using OC and ASN function.
7. Evaluation of SPRT for Normal and Exponential distributions using OC and ASN function.
8. One sample Nonparametric tests: Kolmogorov-Smirnov test, sign test, Wilcoxon signed rank test,
9. Two sample Nonparametric tests: Mann-Whitney (Wilcoxon rank sum test), Wald-Wolfowitz Run test,
10. Several sample Nonparametric tests: Kruskal -Wallis test, Friedman's test.

Pedagogy: Practical assignments 1 to 10 have to be first solved manually (using scientific calculators) andexecuted using R-programming.

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Internal Test 1	10
Internal Test 2	10
Attendance	5
Total	**25 Marks**

References

1	Berger, J.O.(1985): Statistical Decision Theory and Bayesian Analysis, 2nd Edition. Springer
2	Bernando, J.M. and Smith, A.F.M.(1993): Bayesian Theory, John Wiley and Sons.
3	Robert, C.P.(2007): The Bayesian Choice: A Decision Theoretic Motivation, Springer.
4	George Casella, Roger L. Berger (2020): Statistical Inference, 2nd ed., Thomson Learning.
5	Rohatagi, V.K.: (2010): Statistical Inference, Wiley Eastern, New Delhi.
6	Hogg Mckean and Craig (2009): Introduction to Mathematical Statistics, 6th edition ,Pearson Prentice Hall.

STCT 352: Theory Paper 8: Sampling techniques and Statistics for national development (Theory)

Program Name	**B.Sc. in STATISTICS**	Semester	**VI**
Course Title	**Sampling techniques and Statistics for national development (Theory)**		
Course Code:	**STCT 352**	No. of Credits	**04**
Contact hours	**60 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Pre-requisite(s):

Course Outcomes (Cos): After the successful completion of the course, the student will be able to:

CO1. Understand the principles underlying sampling as a means of making inferences about a population.

CO2. Understand the difference between probability and nonprobability sampling.

CO3. Understand different sampling techniques.

CO4. To learn to estimate population parameters from a sample.

CO5. Understand official statistical system in India and their functions.

CO6. Understand the role statistics in national development.

Contents of Theory Paper 8	**60 Hrs**
Unit 1: Introduction to sampling theory	10 Hrs
Objectives and principles of sampling theory; Concept of population and sample; Sampling design, Estimators, complete enumeration versus sampling; Planning, execution and analysis of a sample survey; practical problems at each of these stages; basic principle of sample survey; sampling and non-sampling errors; Types of sampling: non-probability and probability sampling, pilot survey.	
Unit 2: Simple random sampling	15 Hrs
Simple random sampling with and without replacement, definition, and procedure of selecting a sample, estimates of population mean, total and proportion, variances and SE of these estimates, estimates of their variances related proofs, sample size determination.	

Unit 3: Stratified sampling and systematic sampling	20 Hrs
Stratification and its benefits; basis of stratification, Technique, estimates of population mean and total, variances of these estimates, proportional, optimum allocations, Neyman's allocation, allocation with cost functions and their comparison with SRS. Practical difficulties in allocation, derivation of the expressions for the standard errors of the above estimators when these allocations are used, estimation of gain in precision, post stratification and its performance. Systematic Sampling: Linear systematic sampling Technique; estimates of population mean and total, variances of these estimates (N=n x k). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.	
Unit 4: National development	15 Hrs
An outline of present official statistical system in India, Role, function, and activities of Central and State Statistical organizations. Methods of collection of official statistics, their reliability and limitations. National statistical office (NSO), Registrar General Office and National Statistical Commission. Scope and content of Population census of India. Population census methods, economic census. Methods of national income estimation, problems in the estimation of national income. System of collection of Agricultural Statistics. . Crop yield, Production Statistics, Crop estimation and forecasting. Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.	

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	**Program Outcomes (POs)**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1.Understand the principles underlying sampling as a means of making inferences about a population.	x	x	x	x					x	x		
CO2.Understand the difference between probability and nonprobability sampling.	x	x	x	x					x	x		
CO3. Understand different sampling techniques.	x	x	x	x					x	x		
CO4. To learn to estimate population parameters from a sample.	x	x	x	x					x	x		
CO5. Understand official statistical system in India and their functions.	x	x	x	x					x	x		
CO6. Understand the role statistics in national development.	x	x	x	x					x	x		

Pedagogy:

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.

2. Students are encouraged to use resources available on open sources.

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Internal Test 1	15
Internal Test 2	15
Assignment/Seminar (7 marks)+Attendance(3marks)	10
Total	**40 Marks**

STCP 352: Sampling techniques and Statistics for nationaldevelopment (Practical)

Course Title	Sampling techniques and Statistics for national development **(Practical)**		Practical Credits	**2**
Course Code	**STCP 352**		Contact Hours	**60 Hours**
Formative Assessment	**25 Marks**	Summative Assessment		**25 Marks**

Practical Content

1. Drawing of random sample under SRSWOR from a given population and estimation of the mean and total and the standard error of the estimator.
2. Drawing of random sample under SRSWR from a given population and estimation of the mean and total and the standard error of the estimator.
3. Construction of Confidence Intervals for mean and total for SRSWR and SRSWOR.
4. Estimation of the proportion, total and the standard errors of the estimators based on a random sample under SRSWR
5. Estimation of the proportion, total and the standard errors of the estimators based on a random sample under SRSWOR.
6. Estimation of the mean, total and the standard error of the estimator under stratified random sampling.
7. Exercise on allocation of samples in Stratified sampling. (Proportional Allocation)
8. Exercise on allocation of samples in Stratified sampling. (Neyman Allocation)
9. Systematic sampling
10. Estimation techniques in official statistics.

Pedagogy: Practical assignments 1 to 10 have to be first solved manually (using scientific calculators) and executed using R-programming.

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Internal Test 1	10
Internal Test 2	10
Attendance	5
Total	**25 Marks**

References	
1	Cochran, W. G. (2007): Sampling Techniques, Third Edition, Wiley India Pvt. Ltd., New Delhi.
2	Changbao Wu and Mary E. Thompson (2020): Sampling Theory and Practice, Springer Nature Switzerland.
3	Raghunath Arnab (2017): Survey Sampling Theory and applications (2017), Elsevier
4	Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
5	Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press
6	Murthy, M. N. (1967): Sampling Theory and Methods, Statistical Publishing Society, Kolkata.
7	Mukhopadhyay P (2008): Theory and methods of survey sampling. Prentice-Hall of India, New Delhi
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9	Singh, D. and Chaudhary, F. S. (1986): Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd., New Delhi.
10	Sukhatme, P.V., Sukhatme, B. V.(1984): Sampling theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.
11	Sampath S. (2005): Sampling Theory and Methods, Second edition, Narosa, New Delhi.
12	Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi. http://mospi.nic.in/