Learning Outcomes based Curriculum Framework (LOCF) for Statistics Undergraduate Programme B.A./B.Sc. (Honors) 2022

PREAMBLE

Statistics is a science which deals with numerical data in which raw data is converted into useful information. Statistics as a subject is an important branch of knowledge and is devoted to various techniques of collection, presentation, analysis and interpretation of data. It is a science of learning from data. The subject provides tools for making decisions when conditions of uncertainty prevail. In the modern times where large amount of data can be collected through the use of information technology, Statistics has become a very useful tool to analyse these data and extract useful information which primarily helps people in making decision in the most beneficial way. Hence Statistical tools and techniques are used in almost all fields which are indispensable for people working in fields like agriculture, business, management, economics, finance, insurance, education, biotechnology and medical science, etc. For the last two decades, huge amount of data has been handled with the help ofComputers and more sophisticated statistical techniques are employed in an effective manner to draw valid conclusions. Thus, the knowledge of different aspects of Statistics has become beneficial in the present times. Consequently, the demands for employable statisticians are on the increase day by day in various fields of research, business, management, information technology, etc. The syllabi of the Bachelor's Certificate, Bachelor's Diploma, Bachelor's Degree and Bachelor's Degree with Honours degree course in Statistics are framed in such a way that the students at the end of the course, can acquire adequate knowledge of Statistical techniques in both theory and practice. This will help the students for pursuing higher studies and simultaneously can apply statistical tools judiciously to a variety of data sets related to different fields.

1. Introduction

B.A/ B.Sc. (Honours.) Statistics programme consists of 182 credits spread over eight semesters. Each credit has one hour of class room teaching per week. This programme emphasizes both theory and applications of statistics and is structured to provide knowledge and skills in depth necessary for the employability of students in industry, other organizations, as well as inacademics.

2. Learning Outcomes Based Approach to Curriculum Planning

2.1 Nature and Extent of the B.A./B.Sc. (Honours)Programme

The B.A./B.Sc. (Honors.) Statistics Programme has some unique features such as independent projects, a number of elective courses including practical training on realistic problems, and extensive insight into statistical computations using standard statistical packages. Standard statistical packages, namely, MINITAB, MATLAB, R, MATHEMATICA, SAS, S-SPLUS, STATISTIKA, etc. are used in all practical courses and project work. The course has been designed in such a way that besides the core courses, a student can optf or outcome based elective courses from the streams such as *Financial Statistics, Bio- Statistics, Geo-Statistics, Actuarial Statistics, Computational Statistics, Time Series, Clinical Trials, Epidemiology, etc.*
The independent project work is one of the important components of this programme which will focus on one of the streams opted by the candidate.
B.A./B.Sc. (Honours) Statistics programme is of four years duration, with eight semesters pattern.

- During first two semesters, students will be given the basic information that includes methods of data representation and summarization. Further, they will be introduced to probability and distributions along with applications.
- During third and fourth semesters**,** students are expected to study statistical inference, regression analysis, numerical analysis and sampling techniques.
- During fifth and sixth semesters, some theory papers and practicals deal with theoretical as well as applications of statistics.
- During seventh and eight semesters, sometheory papers and practical deal with theoretical as well as applications of Statistics.Besides, in eight semester, they are supposed to take up a Project Work preferably on a problem related to social data, agricultural data, health data, etc.

2.2 Aims of Bachelor's degree ProgrammeinStatistics

- To prepare graduates who are not only statistically sound but also capable of using their appropriate statistical skills in interdisciplinary areas such asfinance, health, agriculture, business, industry, telecommunication, bio- statistics etc. As are sult, they can pursue their future career either in the core field or in the applied field of Statistics.
- To familiarize students wit computational techniques and soft ware used in the statistical arena.
- To provide a soli ground in the best practices of collating and disseminating information.
- To prepare students for undertaking furtherstudy.
- To each students to construct practicable statistical situations in the real-world.

3. Graduate Attributes in Statistics

- **Disciplinary Knowledge**: The proposed curriculum is expected to provide the students a sound knowledge of Statistics covering various aspects. As a result, they will not only appear appropriate for pursuing higher studies in the subject but also develop skill to apply the statistical tools in the real life problems.
- **Critical Thinking**: The proposed course is designed to enrich the students with ability to examine the various statistical issues in a more logical and methodical manner. It is expected that the students will strengthen themselves logically, computationally and analytically.
- **Problem Solving**: The students will be able to critically examine various hypotheses and research queries, and will be able to identify and consult relevant resources to find their rational answers.
- **AnalyticalReasoning**: The students are expected to develop acability to identify logical flaws and loopholes in analyzing and synthesizing data for drawing conclusions.
- **Research Related Skills:** The students should be able to develop original thinking for formulating new problems and providing their solutions. As a result, they will be able to develop research related skills for their own subject as well as for those who are practicing Statistics.
- **Communication Skills and Team Work:** The students are expected to develop effective and confident Communication skill after completion of the course.They will have an ability to work in ateam as well asinisolation.
- **Moral and Ethical Awareness**: After completion of the course, the students are expected to develop ethical and social responsibility as well. As a result, the students will be able to identify ethical issues, avoid unethical behaviour such as fabrication,falsification or misrepresentation and misinterpretation of data.
- **Scientific Reasoning:** The students will be able to analyse, interpret and draw appropriate conclusions from both quantitative and qualitative data and critically evaluate ideas, evidence and experiences with an unbiased and consistent approach.
- **Reflectivethinking:**The students should be sensitive to real experiences with respect to self, society and nation.
- **Information/Digitalliteracy:**The proposed course is expected to develop digital literacy among the students for using ICT in different learning situations. The students should be able to equip themselves with in depth programming and simultaneously use appropriate Statistical software for advanced Statistical computing with high level graphical interface.
- **Self-directed Learning:** The students are expected to be familiar with data collection, compilation, analysis and interpretation and writing of project reports independently.
- **MulticulturalCompetence:**The students are expected to be aware of values and beliefs of different cultures and have a global perspective by examining various forms of primary and secondary data resources.
- **Leadership Readiness/Qualities:** The students will be capable of mapping out the tasks of a team or an organization, formulating an inspiring vision, buildinga team for achieving the desired objectives, motivating and inspiring team members accordingly, and using

management skills to guide people in the right direction smoothly and efficiently.

- **Lifelong Learning:** The proposed course is designed to develop independent, coherent and decisive thoughts among the students that will ultimately develop competency in their lives. Simultaneously, they will develop entrepreneurship and intraprenuership aptitude. This latter aspect will help them achieve risk-taking and innovative ability, an essential requirement of any large organization.

4. Qualification Descriptors

Qualification descriptors for a Bachelor's Degree with honours: The qualification descriptors for a Bachelor's degree with honours will demonstrate (i) a systematic, extensive, coherent knowledge of an academic field of study and its applications, links to interdisciplinary areas of study with a critical knowledge of the subject and a number of emerging issues,(ii) procedural knowledge that creates professionals in the field of, teaching, government and public services, (iii) skills in areas related to specialization and current developments in Statistics.

- Demonstrate skills in collection of relevant quantitative and/or qualitative data, analysis and interpretation of data using appropriate statistical methodologies.
- Use knowledge, understanding and skills for critical assessment of a wider range of ideas and complex problems and issues relating to the chosen field of study.
- Communicate the results of studies undertaken in statistics in arrange of different contexts using them in concepts, constructs and techniques of the subject.
- Address one's learning needs relating to current and emerging areas of study, making use of research, development and professional materials as appropriate, including those related to new frontiers of knowledge.
- Apply one's statistical knowledge and skills to new contexts and to identify and analyse problems and issues and seek solutions to real-life problems.
- Demonstrate subject-related skills that are relevant to some of the job trades and employment opportunities.

5. Programme Learning Outcomes in B.A/B.Sc. (Hons.)Statistics

The student graduating with the Degree B.Sc. (Honors) Statistics should be able to

1. Demonstrate the ability to use skills in Statistics and its related areas of technology for formulating and tackling Statistical related problems and identifying and applying appropriate principles and methodologies to solve a wide range of problems associated with Statistics.
2. Acquire
   (i) A fundamental/systematic or coherent understanding of the academic field of Statistics, its different learning areas and applications in Medical Statistics, Actuarial Statistics, Agricultural Statistics, Geo-Statistics, Financial Statistics, Population Statistics, Financial Econometrics, Clinical Trials and Epidemiology, Queuing Theory, Stochastic Processes,etc.,
   (ii) Procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Statistics, including professionals engaged in research and development, teaching and government/public service;
   (iii) Skills in areas related to one's specialization area within the disciplinary/subject area of Statistics and current and emerging developments in the field of Statistics.
3. Recognize the importance of statistical modeling simulation and computing, and the role o fapproximation and mathematical approaches to analyze the real world problems.
4. Plan and execute Statistical related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relatingthe conclusions/findings to relevant theories ofStatistics.
5. Demonstrate relevant generic skills and global competencies suchas

   (i) Problem-solving skills that are required to solve different types of Statistics- related problems with well-defined solutions, and tackle open-ended problems that belong to the

disciplinary-area boundaries;

(ii) Investigative skills, including skills of independent investigation of Statistics- related issues and problems;

(iii) Communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;

(iv) Analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Statistics and ability to translate them in simple language when needed;

(v) ICT skills;

(vi) Personal skills such as the ability to work both independentlyand in a group.

6. Demonstrate professional behavior such as

(i) Being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;

(ii) The ability to identify the potential lethical issues in work-related situations;

(iii) Appreciation of intellectual property, environmental and sustainability issues; and

(iv) Promoting safe learning and working environment.

6. Credit structure and total:

Credit structure

Semester	Core(Credit)	DSE(Credit)	GEC(Credit)	AECC(Credit)	SEC (Credit)	VAC (Credit)	Semester Credit
I	Core-1 (6)			AECC-1 (4) English/MIL	SEC-1 (4)	VAC-1 (2)	24
	Core-2 (6)					VAC-2 (2)	
II	Core-3 (6)			AECC-2 (4) Environmental Sc.	SEC-2 (4)	VAC-3 (2)	24
	Core-4 (6)					VAC-4 (2)	
Exit option with Bachelor's Certificate in a Discipline on completion of courses equal to a minimum of 46 Credits							
III	Core-5 (6)		GEC-1 (6)			VAC-5 (2)	26
	Core-6 (6)						
	Core-7 (6)						
IV	Core-8 (6)		GEC-2 (6)			VAC-6 (2)	26
	Core-9 (6)						
	Core-10 (6)						
Exit option with Bachelor's Diploma in a Discipline on completion of courses equal to a minimum of 96 Credits							
V	Core-11 (6)	DSE-1 (6)	GEC-3 (6)			VAC-7 (2)	26
	Core-12 (6)						
VI	Core-13 (6)	DSE-2 (6)	GEC-4 (6)			VAC-8 (2)	26
	Core-14 (6)						
Exit option with Bachelor's Degree in a Discipline on completion of courses equal to a minimum of 140 Credits							
VII	Core-15 (6)	DSE-3 (6)	GEC-5 (6)				24
	Core-16 (6)						
VIII	Core-17 (6)	DSE-4 (6)	GEC-6 (6)				24
	Core-18 (6)	Project					
Award of Bachelor's Degree with Honours in a Discipline on completion of courses equal to a minimum of 182 Credits							

Credit total

Course	Credits
I. Core Course	
(18Theory papers of 4 credits each)	18X4=72
(6Practicals of 4 redits each)	6X4=24
(2Practicals of 6 credits each)	2X6=12

	Total 108 credits
II. ElectiveCourse	
A. Discipline Specific Elective(DSE)	
(3 Theory papers of 4 credits each)	3X4=12
(3 Practicals of 2 credits each)	3X2= 6
(1 project of 6 credits)	1X6= 6
B. Generic Elective/Interdisciplinary(GE)	
(6Theory papers of 4 credits each)	6X4 = 24
(6Practicals of 2 credits each)	6X2=12

	Total 60 credits

Optional Dissertation or project work inplace of one Discipline Specific Elective paper (6 credits)in 8th semester.

III. Ability Enhancement Courses	
1. Ability Enhancement Compulsory Courses(AECC)	
(2Theory papers of 4 credits each)	2X4=8
2. Skill Enhancement Courses(SEC)	
(2Theory papers of 3 credits each)	2X3=6
(2Practicals of 1 credit each**)**	2X1=2

	Total 16 credits
	Grand total: 184 credits

7. Course Structure

SEMESTER –I

STC101T	Descriptive Statistics	Core	04
STC102T	Probability Theory-I & Distributions-I	Core	04
STC101P	Practical –based on STC101T& STC102T	Core	04
	Any one from AECC (English/MIL)	AECC-1	04
STS101T	Computational Techniques and R Programming	SEC-1	04
	Any one from the list of VAC	VAC-1	02
	Any one from the list of VAC	VAC-2	02

SEMESTER II

STC103T	Statistical Methods – I	Core	04
STC104T	Distributions - II, Estimation – I and Probability Theory-II	Core	04
STC102P	Practical –based on STC103T & STC104T	Core	04
	Any one from AECC(Environmental Science)	AECC-2	04
STS102T	Statistical Techniques for Research Methodology	SEC-2	04
	Any one from the list of VAC	VAC-3	02
	Any one from the list of VAC	VAC-4	02

SEMESTER III

STC205T	Statistical Methods-II and Index Number	Core	04
STC206T	Statistical Inference-I, Basic Mathematics and Matrices-1	Core	04
STC207T	Sampling Techniques& Official Statistics	Core	04
STC203P	Practical based on STC205T, STC206T & STC207T	Core	06
STG201T	Introduction to Statistics I	GEC-1	04
STG201P	Practical based on STG201T	GEC-(P)	02
	Any one from the list of VAC	VAC-5	02

SEMESTER IV

STC208T	Regression Analysis	Core	04
STC209T	Statistical Inference-II	Core	04
STC210T	Numerical Analysis	Core	04
STC204P	Practical –based on STC208T, STC209T &STC210T	Core	06
STG202T	Introduction to Statistics II	GEC-2	04
STG202P	Practical –based on STG202T	GEC-2(P)	02
	Any one from the list of VAC	VAC-6	02

SEMESTER V

STC311T	Optimization Techniques	Core	04
STC312T	Statistical Quality Control andReliability	Core	04
STC305P	Practical –based on STC311T &STC312T	Core	04
STD301T	Time Series Analysis	DSE-1	04
ST D301P	Practical based on STD301T	DSE-(P)	02
STG303T	Introduction to Probability	GEC-3	04
STG303P	Practical based on STG303T	GEC-3(P)	02
	Any one from the list of VAC	VAC-7	02

SEMESTER VI

STC313T	Design of Experiments	Core	04
STC314T	Non-Parametric Inference	Core	04
STC306P	Practical based on STC313T & STC314T	Core	04
STD302T	Applied Statistics	DSE-2	04
STD302P	Practical based on STD302T	DSE-2(P)	04
STG304T	Introduction to Statistical Inference	GEC-4	04
STG304P	Practical based on STG304T	GEC-4(P)	02
	Any one from the list ofVAC	VAC-8	02

Semester – VII

STC415T	Real Analysis& Measure Theory-I	Core	04
STC416T	Linear Algebra, Matrices–II and Statistical Inference-III	Core	04
STC407P	Practical based on STC416T	Core	04
STD403T	Survival Analysis	DSE-3	04
STD403P	Practical based on STD403T	DSE-3(P)	02
STG405T	Introduction to Applied Statistics	GEC-5	04
STG405P	Practical Based on STG405T	GEC-5(P)	02

Semester - VIII

STC417T	Measure Theory-II & Statistical Inference-IV	Core	04
STC418T	Linear Model, Sum of Squares, Sample Survey-IV	Core	04
STC408P	Practical based on STC417T & ST418T	Core	04
STD404P	Project (based on sample survey/Design of experiments/Demography/Survival analysis/ etc.)	DSE-4(P)	06
STG406T	Introduction to Operations Research	GEC-6	04
STG406P	Practical based on STG406T	GEC-6(P)	02

Discipline Specific Elective Papers (6 credits each) (Any 3 papers to be selected and project in 6th semester is compulsory)

STD301T: Time Series Analysis

STD302T: Applied Statistics

STD403T: Survival Analysis

STD404P: Project (based on Sample Survey/Design of Experiments/Demography/Survival Analysis/ etc.)) (Compulsory) Project may be in 8th semester

Generic Electives/Interdisciplinary Papers (6 credits each) (Statistics students will opt 6 GE papers offered by other Departments/Disciplines. Students from other Departments/disciplines shall take the 6 following 5 GEcourses.)

STG201T: Introduction to Statistics-I

STG202T: Introduction to Statistics-II

STG303T: Introduction to Probability Theory

STG304T: Introduction to Statistical Inference

STG405T: Introduction to Applied Statistics

STG406T: Introduction to Operations Research

Skill Enhancement Courses (4 credits each) (Any 2 papers to be selected)

STS101T: Computational Techniques and R Programming

STS102T: Statistical Techniques for Research Methodology

Syllabi of Core Courses

Paper code: STC101T Discriptive Statistics

Learning outcomes:

Students will acquire

(a) Knowledge of Statistics and its scope and importance in various are as such as Medical, Engineering, Agricultural, Social Sciences, etc.

(b) Information about various Statistical organisations in India and their functions for societal developments,

(c) Knowledge of various types of data, their organization and evaluation of summary measures such as measures of central tendency and dispersionet.

(d) Knowledge of other types of data reflecting quality characteristics including concepts of independence and association between two attributes,

Contents:

Unit I: Statistics and its sources 1 credit (13 lectures)

Introduction to Statistics, Meaning of Statistics as a Science, Importance of Statistics.Scope of Statistics in Industry, Biological sciences, Medical sciences, Economics, Social Sciences, Management sciences, Agriculture, Insurance, Information technology, Education and Psychology.

Statistical Organization in India and their functions:

- Central Statistics Office (CSO) (Definition, organizational structure and functions only) Indian Statistical Institute, Calcutta (ISI) Definition and functions only)
- National Sample Survey Organization (NSSO) (Definition, Organizational Structure & present activities only)
- International Institute of Population Studies, Deonar, Mumbai (IIPS) – Definition and functions only.
- Directorate of Economics and Statistics (DES) at the States of India (formally known as Bureau of Economics and Statistics) - Definition, structure and function only.

Population and Sample

Notion of a statistical population: Finite population, infinite population, homogeneous population and heterogeneous population. Notion of a sample and a random sample.

Measurements and scale:

- Data, Types of data : Quantitative and Qualitative date
  Quantitative : Variables: Interval scale, ratio scale, discrete and continuous variables,
  Qualitative : Attributes – Nominal scale and Ordinal Scale.
- Linear scale and Circular Scale:
- Types of data : (a) Primary data (b) Secondary data (c) Cross-sectional data (d) Time series data and (e) directional data.

Presentation of Data:

- Graphical presentation of data : Bar diagram (simple, multiple, sub-divided, percentage), pie diagram, pictogram, cartogram, stem and leaf chart.
- Classification : Raw data and its classification, discrete frequency distribution, continuous frequency distribution, inclusive and exclusive methods of classification, open-end classes, cumulative frequency distribution
- Graphical presentation of frequency distribution : Histogram, frequency curve, frequency polygon, O-give curves,

Unit II : Measures of Central Tendency & Measures of Dispersion

A. Measures of Central Tendency **1 credit (13 lectures)**

- Notion of Central Tendency : Average, characteristics of an ideal average.
- Arithmetic Mean (A.M): Definition, effect of change of origin and scale, combined mean of a number of groups, merits and demerits, its applications.
- Mode: Definition, formula for computation (with derivation), graphical method of Determination of mode, merits and demerits, its applications.
- Median : Definition, formula for computation (with derivation), graphical method of Determination of median, merits and demerits, its applications.
- Empirical relation between mean, median and mode.
- Partition Values : Quartiles, Deciles and Percentiles, their applications.
- Geometric Mean (G.M) : Definition, merits and demerits, its applications
- Harmonic Mean (H.M) : Definition, merits and demerits, its applications
- Relation between A.M., G.M., and H.M.
- Weighted Mean : Weighted A.M., G.M., and H.M.
- Box-plot

B. Measures of Dispersion

- Concept of dispersion, characteristics of an ideal measure of dispersion.
- Range : Definition, merits and demerits.
- Semi-interquartile range (Quartile deviation).
- Mean deviation : Definition, merits and demerits, minimality property (without proof).
- Mean square deviation : Definition, , minimality property of mean square deviation (with proof), Variance and standard deviation – definition, merits and demerits, effect of change of origin and scale.
- Determination of variance of a combine series.
- Measures of dispersion for comparison : coefficient of range, coefficient of quartile Deviation and coefficient of mean deviation, coefficient of variation (C.V.)

Unit-III : Moments, Skewness and Kurtosis 1credit (13 lectures)

A. Moments

- Raw moments for grouped and ungrouped data.
- Moments about arbitrary constant for grouped and ungrouped data.
- Central moments for grouped and ungrouped data, Effect of change of origin and Scale, Sheppard's correction for moments upto fourth order(without proof).
- Relations between central moments and raw moments (upto fourth order).
- Karl Pearson's β and $\sqrt{}$ coefficients

B. **Skewness and Kurtosis**

- Concept of skewness of frequency distribution, positive, negative skewness, symmetric frequency distribution.
- Bowley's coefficient of skewness.
- Karl Pearson's coefficient of skewness
- Measures of skewness based on moments
- Concepts of kurtosis, leptokurtic and platykurtic frequency distributions.
- Measures of kurtosis based on moments

Unit – IV : Theory of Attributes **1 credit (13 lectures)**

- **Attributes** : classification, notion of manifold classification, dichotomy, class-frequency. order of class, positive class-frequency, negative class frequency, quanta class-frequencies, ultimate class frequency, relationship among different class frequencies (upto three attributes), dot operator to find the relation between frequencies, fundamental set of class frequencies.
- Consistency of data up to 3 attributes), condition for consistency of data.
- Concepts of independence and association of two attributes.
- Yule's coefficient of association (Q)

Books Recommended

1. Goon, A.M.,GuptaM.K.and Dasgupta, B.(2013) Fundamentals of Statistics, Vol. 1, The World Press Pvt.Ltd., Kolkata.
2. Agarwal, B. L.(2006): Basic Statistics, New Age International Publishers.
3. Kapur, J.N. & Saxena, H.C. (2019) : Mathematical Statistics, S. Chand & Co., New Delhi
4. Medhi, J. (1992): Statistical Methods Wiley Eastern
5. Mukhopadhyay, P. (2016): Mathematical Statistics, New Central Book Agency, Calcutta,
6. Gupta, S.C. and Kapoor, V.K. (2019): Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.

Course code: ST-C102TProbability Theory-I and Distributions-I

Learning Outcomes:

Students will acquire

(a) ability to distinguish between random and non-random experiments,
(b) knowledge to conceptualise the probabilities of events including frequentist and axiomatic approach Simulteneously, they will learn the notion of conditional probability including the concept of Bayes' Theorem,
(c) knowledge related to concept of discrete random variable and its probability distribution including expectation and moments,
(d) knowledge of important discrete distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hyper-geometric and their interrelations if any,
(e) acumen to apply standard discrete probability distribution to different situations.

Contents :

Unit – I : Set Theory **1 credit (13 lectures)**

- Set types of set, operations o sets and their properties (with proof)|
- Intervals- open, closed sets, compact set and their elementary properties.
- Countable and uncountable sets, open and closed sets, compact set and their elementary properties.
- Definition of field of sets, sigma-field and their elementary properties.
- Measure, measure space, elementary properties of measure.

Unit – II : Probability **1 credit (13 lectures)**

- Experiment, Types : Deterministic and Non-deterministic (Random) experiment, concept of Statistical regularity.
- Sample space for discrete, finite and countably infinite.
- Events : Types : (i) Exaustive, Favourable, Equally likely, Mutually exclusive, independent, certain, uncertain, impossible, (ii) Algebra of events and its representation in set theory notation. Occurrence of following events. (i) at least one of the given events, (ii) none of the given events, (iii) all of the given events, (iv) mutually exclusive events, (v) mutually exhaustive events, (vi) exactly one event out of the given events.
- Statistical (their criticism) and axiomatic,
- Elementary properties of probability:i) $P(\emptyset) = 0$ ii) $P(A) = 1 - P(A^c)$ iii) If $A \subseteq B$, then $P(A) \leq P(B)$iv) $P(A^c \cap B) = P(B) - P(A \cap B)$

- Definition of conditional probability of an event. Definition of independence of two events. Pairwise independence and mutual independence for three events. Addition and Multiplication Theorem and its generalization. (Bool's inequality)

Unit – III :Bayesian Probability and Random variable 1 credit (13 lectures)

- Bayes' Theorem : Partition of the sample space, Proof of Bayes' theorem, Applications of Bayes' theorem in real life.
- Definition of random variable, Types of random variables – discrete and continuous
- Probability Mass Function (pmf) and its properties,
- Distribution function (df) of a discrete r.v. and its properties, Mode and median of a univariate discrete probability dist$^{n.}$
- Continuous sample space : Definition, illustrations. Continuous random variable: Definition, probability density fuction (p.d.f.), cumulative distribution function (c.d.f.) properties of c.d.f. (without proof),

Unit – IV Two-dimensional random variable 1 credit (13 lectures)

Definition of two-dimensional discrete and continuous random variable, joint p.m.f and p.d.f., distribution function and properties, concept of identically distributed r.v.s. Computation of probabilities of events in bivariate probability distribution. Concepts of marginal and conditional probability distributions and its properties (without proof). Definition of raw and central joint moments, joint m.g.f., joint c.g.f. Relation between p.d.f. and distribution function.

Independent r.v's., pairwise independence and mutual independence for 3 events.

Transformation of r.v.'s (upto 2 r.v.'s), Jacobian of a transformation.

Books Recommended

1. Goon, A.M.,GuptaM.K.and Dasgupta, B.(2013) Fundamentals of Statistics, Vol. 1, The World Press Pvt.Ltd., Kolkata.
2. Agarwal, B. L.(2006): Basic Statistics, New Age International Publishers.
3. Kapur, J.N. & Saxena, H.C. (2019) : Mathematical Statistics, S. Chand & Co., New Delhi
4. Medhi, J. (1992): Statistical Methods Wiley Eastern
5. Mukhopadhyay, P. (2016): Mathematical Statistics, New Central Book Agency, Calcutta,
6. Gupta, S.C. and Kapoor, V.K. (2019): Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.
7. Singh, B. M. (2004): Measure, Probability and Stochastic Processes, South Asian Publishetrs, New Delhi.

Course code: STC101P Practical based on STC101T and STC102T 4 credits

Learning outcomes:

Students will acquire

(a) ability to distinguish between random and non-random experiments,

(b) knowledge to conceptualise the probabilities of events including frequentist and axiomatic approach. Simultaneously, they will learn the notion of conditional probability including the concept of Bayes'Theorem,

(c) knowledge related to concept of discrete random variable and its probability distribution including expectation and moments,

(d) knowledge of importan discrete distributions such as Binomial, Poisson,Geometric, Negative Binomial and Hyper-geometric and their interrelations if any,

(e) acumen to apply standard discrete probability distribution to different situations.

List of Practicals:

1. R programming, importing and exporting data, R functions, loops, conditional statements, R graphics. (2 Practicals)
2. Diagrammatic representation of statistical data problems based on simple and subdivided bar diagrams, pie diagram. (2 Practicals)
3. Construction of Frequency Distribution and its graphical representation of statistical data.

(3 Practicals)

4. Computation of measures of central tendency and dispersion. Use of an appropriate measure and interpretation of results. (4 Practicals)
5. Moments, Measures of skewness and kurtosis, Box plot. (4 Practicals)
6. Fitting of binomial distribution and computation of expected frequencies, mean variance, m.g.f.
7. Fitting of Poisson distribution and computation of expected frequencies, mean variance, m.g.f.
8. Fitting of geometric distribution and computation of expected frequencies, mean variance, m.g.f.
9. Fitting of hypergeometric distribution and computation of expected frequencies, mean variance, m.g.f.
10. Fitting of negative binomial distribution and computation of expected frequencies, mean variance, m.g.f.
11. Consistency of data up to 2 attributes. Concepts of independence and association of two attributes. (2 Practicals)
12. Yule's coefficient of association (Q), interpretation. Examples and Problems.(2 Practicals)

Course code: STC103T Statistical methods - I

Unit –I Expectations 1 credit (13 lectures)

- Mathematical expectation of a r.v. (both discrete and continuous) and its properties E(a)=a, ii) E(aX)=a E(X), Addition and Multiplication theorems of expectation,
- Variance and covariance ofr.v.'s in terms of expectation, variance and covariance of r.v.'s of linear forms –(i) Cov(aX, bY) = ab Cov(X,Y) (ii) Cov(X+a,Y+b)=Cov(X,Y) (iii)Cov$[(X-\bar{x}/\sigma_x , (Y-\bar{y}/\sigma_y] = [1/(\sigma_x\sigma_y)]$ Cov(X,Y) (iv) Var(aX)= a^2Var(X), (v) Variance of the sum and variance of the difference of two random variables, (vi) Standardized random variable.

Unit-II :Generating functions 1 credit (13 lectures)

Theorems on Conditional expectation and conditional variance.

- Moment generating function(mgf) (both discrete and continuous r.v.'s) and its its properties-

i) $M_{cx}(t)=M_x(ct)$ ii) $\boldsymbol{M}_{x_1+x_2+\ldots+x_n}=\boldsymbol{M}_{x_1}(\boldsymbol{t})\,\boldsymbol{M}_{x_2}(\boldsymbol{t})\ldots\boldsymbol{M}_{x_n}(\boldsymbol{t})$

iii)Effect of change of origin and scale iv) Uniqueness theorem

- Cumulating generating function and its properties-

i) Additive property of cumulants ii) Effect of change of origin on cumulants

- Probability generating function (for discrete r.v) and convolution

-Moments from fusing :i) Expansion method (ii) Differentiation method,

-Relation between moments and cumulants(without proof) upto fourth order

-Characteristic function and its properties (without proof).x_1

Unit-III : Discrete probability distributions 1 credit (13 lectures)

Variance, standard deviation (s.d.) and Coefficient of variation(c.v.) of univariate probability distribution, effect of change of origin and scale on mean, variance and s.d., raw, central and factorial raw moments of univariate probability distributions and their interrelations(without proof). Coefficients of skewness and kurtosis based on moments.

Some standard discrete probability distributions :

- Bernoulli Trial, Bernoulli distribution
- Binomial distribution and its derivation, Evaluation of its mean, variance, cdf, mgf and cgf, its properties.
- Poisson distribution and its derivation as a limiting case of binomial distribution, Evaluation of its mean, variance, cdf, mgf and cgf, its properties
- Rectangular (uniform) discrete distribution Geometric dist^n., Negative binomial dist^n., and

Hypergeometric dist^{n}, - their means, variance, cdf and mgf.
- Degenerate dist^{n}. (one-point dist^{n}) and its mean and variance.

Unit-IV : Correlation **1 credit (13 lectures)**

- Correlation : Bivariate data, scatter diagram and its interpretation, bivariate frequency table and its required terms, difference between bivariate frequency dist^{n}. table, correlation table and contingency table concept of correlation between two variables. Interpretation of psotive, negative and no correlations.
- Karl Pearson's correlation coefficient (r) : Derivation (ungrouped data) and interpretation Assumptions, Properties : (i) -1 (with proof), ii) Effect of change of origin and scale (with proof)
- Spearman's correlation coefficient : Concept and interpretation, derivation (both in without and with ties), and its limits.

Recommended Books:

1. Goon, A.M.,GuptaM.K.and Dasgupta, B.(2013) Fundamentals of Statistics, Vol. 1, The World Press Pvt.Ltd., Kolkata.
2. Agarwal, B. L.(2006): Basic Statistics, New Age International Publishers.
3. Kapur, J.N. & Saxena, H.C. (2019) : Mathematical Statistics, S. Chand & Co., New Delhi
4. Medhi, J. (1992): Statistical Methods Wiley Eastern
5. Mukhopadhyay, P. (2016): Mathematical Statistics, New Central Book Agency, Calcutta,
6. Gupta, S.C. and Kapoor, V.K. (2019): Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.
7. Singh, B. M. (2004): Measure, Probability and Stochastic Processes, South Asian Publishetrs, New Delhi.

STC104T: Distributions-II, Estimation-I and Probability Theory

Learning Outcomes:

After going through this course, the students will get

(a) a fundamental understanding of Parametric models for developing relevant inferences on associated parameters,

(b) knowledge of point and interval estimation procedures and different methods of point estimation,

(c) to understand the Cramer-Rao Inequality, Rao Blackwell and Lehmann Scheffe theorems and their applications in obtaining Minimum Variance Unbiased and Minimum Variance Boundestimators,

(d) to work on several standard examples to help them understand the various inherent concepts.

Unit – I:Distribution –II **1 credit (13 lectures)**

Some standard univariate continuous probability distributions:

- Normal distribution : Definition, Derivation as a limiting case of binomial distribution, mean, median, mode, quartiles, mean deviation, variance, moments, point of inflexion, area properties of normal curvemgf, characteristic function (uncluding standard normal variable), importance and properties (without proof derivation).
- Uniform dist^{n}., Exponention, Carrchy, Beta (both first and second), Gammal (both first and second), Weibuldist^{n} : derivation of first two moments and mgf of these distributions.

Unit – II : Theory of estimation-I **1 credit (13 lectures)**

- Concept of parameter and parametric space, random sample, statistic, sampling distribution(only definition)
- Concept of estimation and its problems, estimate, estimator etc.
- Types of estimation: Point and interval estimations
- Criteria of a good estimator- unbiasedness, consistency, sufficiency and efficiency, with simple examples.

- Methods of point estimation- Maximum likelihood estimation (mle), least square, moments and minimum x^2.
- Properties of m.l.e. (without proof), application of the method of m.l.e and method of moments – for obtaining estimates of the parameters of binomial, Poisson and Normal distributions.

Unit – III : Sampling Distributions. 1 credit (13 lectures)

- Concept of Sampling distribution and Standard error (SE)
- SE of sample mean, proportion, difference of two means, and difference of two proportions(with derivation)
- sampling distribution of sum of binomial and poissonr.v.'s and mean of normal disgtribution
- sampling distribution of linear function(y=a+bx) and square of a normal variate
- for a random sample (x_i, i=1,2,…,n) drawn from a normal population with mean μ and variance $\mathfrak{e}^2$ show by using linear orthogonal transformation that

$\bar{x}$ ~N(μ,$\frac{\partial^2}{n}$), $\bar{x}$ = sample mean and (ii) $\bar{x}=\frac{1}{n}\sum x_i$

and$\frac{ns^2}{\partial^2} = \sum_{i=1}^{n} \frac{x_i - x}{\partial}$

- Derivation of t,F,X^2 distributions, shape of its curves and its properties
- Theorems of X^2 distribution
- Relation between t, F and X^2
- Derivation of sampling distribution of sample total correlation coefficient and sample range.
- Fisher's Z transformation (statement only) and its application.

Unit - IV : Laws of Large Number & Central Limit Theorems. 1 credit (13 lectures)

Cauchy-Schwartz(in expectation) and Chebyshev's inequalities and their applications.
Convergence in probability, almost sure convergence, convergence in distribution, convergence of mean square.
Weak law of large number (Bernoulli and Khinchin) and their applications, Strong Law of Large Number (Statement only)
Central limit theorem (iidcse) – (De-Moivre- Laplace and Lindeberg-Levy) with illustration And their application to standard distributions.

Books recommended: From page 43 and above

1. Goon, A.M.,GuptaM.K.and Dasgupta, B.(2013) Fundamentals of Statistics, Vol. 1, The World Press Pvt.Ltd., Kolkata.
2. Agarwal, B. L.(2006): Basic Statistics, New Age International Publishers.
3. Kapur, J.N. & Saxena, H.C. (2019) : Mathematical Statistics, S. Chand & Co., New Delhi
4. Medhi, J. (1992): Statistical Methods Wiley Eastern
5. Mukhopadhyay, P. (2016): Mathematical Statistics, New Central Book Agency, Calcutta,
6. Gupta, S.C. and Kapoor, V.K. (2019): Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.
7. Hanagal,D.D.(2009).Introduction to Applied Statistics:A Non-Calculus Based Approach. Narosa Publishing Comp. NewDelhi.
8. Kendall,M.G. and Stuart,A.(1979).The Advanced Theory of Statistics,Vol.2. Inference and Relationship. 4th Edition. Charles Griffin & Comp.
9. Kendall, M.G., Stuart, A. and Ord, J.K. (1994). The Advanced Theory of Statistics, Vol. 1. Distribution Theory. 6th Edition. Halsted Press (WileyInc.).

STC102P Practical based on STC103T and STC104T
List of practicals :

1. Fitting of Binomial distribution and computation of expected frequencies, mean variance, m.g.f. (2 Practicals)

2. Fitting of Poisson distribution and computation of expected frequencies, mean variance, m.g.f. (2 Practicals)
3. Fitting of geometric distribution and computation of expected frequencies, mean variance, m.g.f. (2 Practicals)
4. Fitting of hypergeometric distribution and computation of expected frequencies, mean variance, m.g.f. . (2 Practicals)
5. Fitting of negative binomial distribution and computation of expected frequencies, mean variance, m.g.f. (2 Practicals)
6. Experiments based on Karl Pearsons correlation coefficient and Spearman's Rank correlation coefficient. . (3 Practicals)
7. Fitting of Normal distribution and calculation of Expected frequency (2 Practicals)

Recommended Books: Same to Recommended Books of STC103T and STC104T

STC205T : Statistical Methods II & Index Numbers

Learning Outcomes:

This course will acquaint the students with

(a) Various basic concepts on sampling distributions and large sample tests based on normal distribution,
(b) Small sample tests based on chi-square,Student's and Snedecor's Fdistributions,
(c) theory of Logistic and ProbitAnalysis,
(d) knowledge of two dimensional discrete and continuous random variables, their associated distributions, characteristics, marginal and conditional distributions,
(e) inferential knowledge regarding the parameters of Bivariate and Multivariate Normal distributions,

Unit – I : Normal Distribution (continuation) 1 credit (13 lectures)

- Standard normamal variable and its pdf
- Pdf curve of normal distributions, identification of scale and location parameters, computations of normal probabilities using normal probability integral tables, additive property, normal probabaility plot and q-q plot to test normality
- Bivariate normal distribution: Derivation properties, marginal and conditional distributions and related problems.

Unit – II : Testing of hypothesis-I 1 credit (13 lectures)

- Statistical hypothesis-simple and composite, null and alternative hypothesis, one and two-tailed test, non-critical and critical region (acceptance and rejection region), level of significance.
- Test of a statistical hypothesis, Type I and II errors, p-value, size of a test, power and power function of test.
- Concept of test of significance, assumptions and their validity
- Large sample test for
  (i) test of single proportion (ii) test for difference of two proportions (iii) test for single mean
  (iv) test for difference of two means

Unit – 3 : Testing of hypothesis –II 1 credit (13 lectures)

- Application of t-distribution:
  (i) test for single mean
  (ii) test for difference of two means (independent and not independent samples)
  (iii) test for sample correlation coefficient
- Application of F-distribution:
  (i) test for the quality of two population variances

- Application of X^2 distribution:
  (i) test for population variance H_o: $o^2=o_o^2$.
  (ii) Test of goodness of fit (1^{st} and 2^{nd} degree equations, Binomial, Poisson and Normal distributions)
  (iii) test of independence of attributes
- Application of Fisher's Z-transformation: To test i) H correlation coefficient

Variance stabilizing transformations

Unit-IV : Index Numbers **1 credit (13 lectures)**

- Introduction, problems involved in the construction of index numbers.
- Laspeyre's, Paasche's, Fisher's, Marshall-Edgeworth, Dorbish-Bowley index numbers.
- Requirements of a good index number – time reversal test, factor reversal test and circular Test, Fisher's index number's reversibility.
- Construction of wholesale and cost of living index number.

Books recommended :

1. Hanagal,D.D.(2009).IntroductiontoAppliedStatistics:ANon-CalculusBased Approach. Narosa Publishing Comp. NewDelhi.
2. Kendall,M.G.and Stuart,A.(1979).The Advanced Theory of Statistics,Vol. 2. Inference and Relationship. 4^{th}Edition. Charles Griffin & Comp.
3. Kendall, M.G., Stuart, A. and Ord, J.K. (1994). The Advanced Theory of Statistics, Vol. 1. Distribution Theory. 6^{th} Edition. Halsted Press (WileyInc.).
4. Kenney, J.F. and Keeping, E.S. (1947). Mathematics of Statistics. Part I. 2^{nd} Edition. Chapman &Hall.
5. Kenney, J.F. and Keeping, E.S. (1951). Mathematics of Statistics. Part II. 2^{nd}Edition. Chapman &Hall.
6. Yule,G.U.and Kendall,M.G.(1973).AnIntroduction to the Theory of Statistics. 14^{th} Edition. Charles Griffin &Comp.
7. Goon, A.M.,GuptaM.K.and Dasgupta, B.(2013) Fundamentals of Statistics, Vol. 1, The World Press Pvt. Ltd., Kolkata.
8. Agarwal, B. L.(2006): Basic Statistics, New Age International Publishers.
9. Kapur, J.N. & Saxena, H.C. (2019) : Mathematical Statistics, S. Chand & Co., New Delhi
10. Medhi, J. (1992): Statistical Methods Wiley Eastern
11. Mukhopadhyay, P. (2016): Mathematical Statistics, New Central Book Agency, Calcutta,
12. Gupta, S.C. and Kapoor, V.K. (2019): Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.

STC206T: Statistical Inference-I, Basic Mathematics& Matrices - I

Learning Outcomes:

After going through this course, the students will get

(a) A fundamental understanding of Parametric models for developing relevant inferences on associated parameters,
(b) Knowledge of point and interval estimation procedures and different methods of point estimation,
(c) to understand the Cramer-Rao Inequality, Rao Blackwell and Lehmann Scheffe theorems and their applications in obtaining Minimum Variance Unbiased and Minimum Variance Boundestimators,
(d) to work on several standard examples to help them understand the various inherent concepts.

Unit –I : Theory of Estimation –II **1 credit (13 lectures)**

- Mean square and minimum mean square error estimator,
- Minimum variance estimator (MVE), MVUE and its uniqueness (with proof), MVUE's from the parameters of Binomial, Poisson and Normal families, Cramer-Rao Lower bound, amount of information
- Consistency of estimators and sufficient conditions for consistency, relative efficiency of an estimator, sufficient estimator, factorization theorem for sufficient estimator, concept of complete sufficient statistics, Rao-Blackwell and Lehmann Scheffe theorems (statements only), Confidence interval, confidence coefficient (one method of obtaining confidence limits), confidence interval for mean and variance of Normal distribution

Unit –II : Theory of Estimation –III 1 credit (13 lectures)

- MVUE's for the parameters of binomial, poisson and normal families, Cramer-Rao inequality and MVB estimators
- BAN and CAN estimators
- Interval estimation, confidence interval, confidence coefficient (one method of obtaining confidence limits), confidence interval for mean and variance of normal distribution.

Unit - III : Basic Mathematics 1 credit (13 lectures)

- Convergence of sequence, Cauchy criterion
- Infinite series: Cauchy criterion for convergence, geometric series, convergence test of positive term series by (i) comparison test (ii) Cauchy's root test (iii) D'sAlember's ratio test (iv) Raabe's test (application only for the above tests)
- Alternating series: test of convergence (Leibnitz test), concept of absolute convergence, conditional convergence
- Lagrange's method of determining multiplier
- Mean Value Theorem of differential calculus.
- Riemann integrability
- Infinite and improper integral (concept only), Gamma and Beta function and their elementary properties (with proof).

Unit - IV : Determinant and Matrices 1 credit (13 lectures)

Determinants: definition as a function of its element, addition and subtraction, properties (without proof), Minors and co-factors, Matrices- definition, types, addition and multiplication., Adjoint, transpose, determinant of a square matrix., Inverse, rank of a square matrix.

Nonsingular matrices and their inverses; determinants of square matrices, elementary row and column operations, ranks, row and column ranks, invariance theorems, Sylvester and Frobenius inequalities; system of homogeneous and non-homogeneous linear equation, their consistency and maximal linearly independent solutions.

Books recommended

1. Bickel,P.J.andDoksum,K.A.(2000).Mathematical Statistics, Second Edition, Prentice Hall.
2. Casella,G.andBerger,R.L.(2001).Statistical Inference, Second Edition, Cengage Learning.
3. Gupta,M.K.,Goon,A.M.,and Dasgupta,B.(2013).An Outline of Statistical Theory, Vol. 2. The World Press Publishers Pvt. Ltd.,Calcutta.
4. Hogg,R.V.,Mc Kean J.W.and Craig, A.T.(2006). Introductionto Mathematical Statistics, Paper back Edition, Pearson.
5. Kale,B.K.(2005).A First Course on Parametric Inference. Alpha Science International Ltd.
6. Mood,A.M.,Graybill,F.A.and Boes, D.C.(2011).Introduction to the Theory of Statistics, 3rd Edition.,(IndianEdition),Tata McGraw-HillPub.Co.Ltd.
7. Rajagopalan,M.and Dhanavanthan,P.(2012).Statistical Inference. PHILearning Pvt. Ltd., NewDelhi.
8. Rao,C.R.(2009).Linear Statistical Inference and its Applications, Second Edition, Wiley.
9. Singh, B. M. (2008); Introductory Linear Algebra, South Asian Publishers Pvt. Ltd. New Delhi

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

STC207T: Sampling Techniques& Official Statistics

Learning Outcomes:
The students shall get

(a) basic knowledge of complete enumeration and sample, sampling frame, sampling distribution, sampling and non-sampling errors, principal steps in sample surveys, limitations of sampling etc.,

(b) introduce to various statistical sampling schemes such as simple, stratified, systematic and pps sampling,

(c) an idea of conducting the sample surveys and selecting appropriate sampling techniques,
(d) knowledge about comparing various sampling techniques
(e) knowledge about various statistical data and records used in the Indian administration.

Unit I : Sample Survey –I 1 credit (13 lectures)

- Introduction, concept of statistical population and sample.
- Difference between census and sample survey, advantages of sample survey over census and vice versa.
- Principles of sampling theory – validity, regularity and optimization.
- Principle steps involved in a large scale sample survey, preparation of questionnaire and schedule, sampling and non-sampling errors.
- Some sampling techniques concept of purposive, quota, snowball and volunteer sampling.
- Simple random sampling (with and without replacement): Notations and terminology, probabilities of selection techniques of selecting a random sample – lottery method & use of Random Number Tables, estimation of population total and mean, variance and S.E. of the estimates, unbiasedness of sample mean for the population mean, merits and demerits, comparison of simple random sampling with and without replacement.
- Simple random sampling of attributes
- Determination of sample size for (i) specified coefficient of dispersion, and (ii) given margin of error in estimate and the confidence coefficient.

Unit – II : Sample Survey-II 1 credit (13 lectures)

- Probability proportional to size (PPS) sampling-Definition and terminology, cumulative total method and Lahiri's methods of selecting PPS sampling with and without replacement.
- Stratified random sampling: definition of strata, advantage of stratification principles of stratification, estimation of population total and mean, variance and SE of its estimates, allocation of samples: (i) equal (ii) proportional (iii) Neyman (optimum), derivation of the variances for proportional and optimum allocation.
- Gain in precision due to stratification: proportional and optimum in comparison with SRS.

Unit – III : Sample Survey – III 1 credit (13 lectures)

- Systematic sampling (linear): techniques of selecting systematic sample, merits and demerits, estimation of population total and population mean and its sampling variance, comparison of systematic sampling with simple random sampling and stratified sampling
- Systematic sampling (circular): Concepts and examples.
- Techniques of : Cluster sampling Two stage and multi-stage sampling, multiphase sampling, double sampling
- Comparison of multistage and multiphase sampling

Unit – IV : Indian Official Statistics 1 credit (13 lectures)

-Statistical system in India, CSO (Central Statistical Office) NSSO, Office of the Registrar General, Directorate-General of Commercial Intelligence and Statistics, Directorate of Economics and Statistics(in states) Labour Bureau, Army Statistical Organisation (features of the organizations and name of their publications only)
-Discussion on the official statistics of India related to census, agriculture and industries,
-Census types of census and type adopted by India, organization of census, type of data included in the

schedule of lst census.

-Agricultural Statistics- Land utilization statistics, total area, classification of area, area under crop, area irrigated, crops irrigated, crop production statistics-forecast crops, non-forecast and plantation crops

-Industrial statistics- Statistics relating to organized and unorganized sectors.

-Study of official publications and journals of North Eastern Council (NEC) and Basic Statistics of NEC.

STC203P: Practical based on STC205T, STC206T & STC207T 6 credits

The list of practical:

1. Experiment based on Large sample tests : (i) test of single proportion (ii) test for the difference of two proportions (iii) test for single mean and (iv) test for difference of two means. (4 Practicals)
2. Test based on F- distribution – test for the equality of two population variances (1 Practical)
3. Test based on Chi-square distribution (i) Test for equality of population varience (ii) Test of goodness of fit (1^{st} & 2^{nd} degree) equations, Binomial, Poisson and Normal distributions and (iii) test of independence of attributes. (9 Practicals)
4. Test based on Fisher's z – transformation : (i) single sample correlation and (ii) two sample correlations coefficients (2 Practicals)
5. Tests based on Laspeyre's, Paasche's, Marshall – Edgeworth, Derbish – Bowley index numbers (1 Practical)
6. Test based on Fisher's index number and test for ideal index number (Fisher's index number) – Factor reversal and time reversal tests (1 Practical)
7. Test based on construction of Wholesale and Cost of Living Indes Number. (2 Practicals)

STC208T : Regression Analysis

Learning Outcomes :

The students shall

(a) Know about correlation and regression techniques, the two very powerful to olsin statistics,

(b) get an idea of Linear, Polynomial and Multiple Linearregression,

(c) learn about regression diagnostics, multicollinearity, residual plots and estimation and tests for regression coefficients.

(d) Study concept of coefficient of determination and inference on partial and multiple correlation coefficients.

Contents:

Unit – I Curve fitting 1 credit (13 lectures)

- Concept of curve fitting
- Method of least square, most plausible values
- Fitting of polynomials (1^{st} and 2^{nd} degree) by lease squares method
- Fitting of polynomials by orthogonal polynomials : Importance of using orthogonal polynomials in curve fitting and derivation of orthogonal polynomials.

Unit – II : Correlation 1 credit (13 lectures)

- Multiple and partial correlation(for three variables), their coefficients and properties, residual and its properties, variance of residuals.
- Multiple and partial correlation coefficient in terms of total correlation coefficients for 3 variables.
- Explained and unexplained variation, coefficient of determination.
- Intra class correlation coefficient (derivation) and its limits.
- Correlation ratio (derivation) and its properties.
- Pearsonian system of curve- Pearsonian general differential equation and derivation of Pearsonian curves of Type-I II and III.

Unit – III : Regression Analysis –I 1 credit (13 lectures)

Linear Regression: Meaning of regression, difference between correlation and regression, simple linear regression model, Estimation of regression parameters by least squares method (fitting of regression model), Interpretation of parameters. Concept of residual, Residual plots, comparison of

two models on the basis of residual sum of squares, Regression diagnostics, Tests for regression diagnostics. Tests for regression coefficients.

Unit –IV : Regression Analysis-II 1 credit (13 lectures)

Multiple linear regression: Estimation of regression parameters by least square method, Interpretation of parameters, Concept of coefficient of determination. Multicollinearity.Inference on partial and multiple correlation coefficients., Test of departure from normality assumption, detection of outliers, test for homogeneity of variance, departure from Gauss-Markov set up, heteroscedasticity, autocorrelation.

Recommended Books: from page 50

Recommended Books:

1.Draper,N.R.andSmith,H.(1998).Applied Regression Analysis. 3Edition. John Wiley.

2. Hosmer,D.W.,Lemeshow, S.and Sturdivant R.X.(2013).AppliedLogistic Regression, Wiley Blackwell.
3. Montgomery,D.C., Peck ,E.A.and Vining, G.G.(2013).Introduction to Linear Regression Analysis.5th Edition. Wiley.
4. Neter,J.,Kutner,M.H.,Nachtsheim,C.J. and Wasserman,W.(1996).Applied Linear Statistical Models, 4th Edition, Irwin USA.

STC 209T : Statistical Inference –II 4 credits

Learning Outcomes :

The course will provide the students with a knowledge of

(a) Advanced level topics in statistical inference on testing of statistical hypotheses for both randomized and non-randomized tests,
(b) Using Neyman Pearson Lemma and finding Uniformly Most Powerful Test,
(c) likelihood ratio test and its applications,
(d) confidence interval estimation and their relationships with testing,
(e) order statistics and their distributions,
(f) Wald'sSequential Probability Ratio Test and concepts of ASN and OC functions,
(g) Sequential estimation with examples based on standard probability distributions,
(h) Statistical decision problem including the concept of loss and risk functions, Bayes and Minimax Decisionrules.

Unit –I : Testing hypothesis –III 1 credit (13 lectures)

- Review of Statistical hypothesis, critical region, size and power of a test,
- Most powerful test and Most powerful critical region (MPCR), Neyman-Pearson lemma and its application in construction of MPCR for testing simple hypothesis against simple alternative for binomial, Poisson and nomal distributions.

Unit –II : Testing of hypothesis- IV & order statistics 1 credit (13 lectures)

- UMPCR, unbiased test, UMPUCR
- Definition of order statistics-derivation of the distribution of rth sample order statistic joint distribution of r^{th} and s^{th} sample order statistics and distribution of range.

Unit –III : Sequential Analysis 1 credit (13 lectures)

- Squential Anlysis :Need for sequential tests. Wald's SPRT, ASN, OC FUNCTION. Brief idea of sequential estimation, examples based on normal, Poisson, binomial and exponential distributions.

Unit – IV :Decision Theory I 1 credit (13 lectures)

- Elements of decision theory, decision problems: Formulation of Decision Problem, expected loss and risk function, Non-randomized and randomized decision rules, estimation and testing viewed as

decision problems and its examples, decision principles, Bayes and Minimax, least favourable distribution, Bayesian analysis, conjugate families of prior distributions, posterior decision analysis, forms of Bayes rules for estimation and testing problem.

Recommended Books :

- Gibbons, J. D (1971): Non-Parametric Statistical Inference, Mc Graw-Hill Book Company.
- Casella,G.andBerger,R.L.(2001).Statistical Inference, Second Edition, Cengage Learning.
- D'AbreraH.J.M.and Lehmann,E.L.(2006).Non-parametrics:Statistical Methods Based on Ranks. PrenticeHall.
- Gupta,M.K.,Gun,A.M.,and Dasgupta,B.(2013).An Outline of Statistical Theory, Vol. 2. The World Press Publishers Pvt. Ltd.,Calcutta.
- Kale,B.K.(2005).AFirst Course on Parametric Inference. Alpha Science International Ltd.
- Rajagopalan,M.andDhanavanthan,P.(2012).Statistical Inference. PHIL earning Pvt. Ltd., NewDelhi.
- Rao,C.R.(2009).Linear Statistical Inference and its Applications, Second Edition, Wiley.

STC 210(T) : Numerical Analysis 4 credits

Learning Outcomes:

The students shall

(a) Demonstrate knowledge of different numerical methods, essential for providing Mathematical support to the Statisticians where intractability becomes severe,

(b) be able to learn various difference, interpolation formulae,

(c) be in a pposition to find solutions to equations using Bisection, Newton Raphson and Regula Falsi Methods,

(d) handle numerical differentiation and integration,

(e) be able to find solutions to difference equations of first order and linear difference equations with constant coefficients.

(f) be able to forcast numerical phenomenon.

Unit –I : Finite Difference –I 1 credit (13 lectures)

- Basic concept of finite difference theory
- Operators- and E and their relations, construction of diagonal and horizontal difference tables, determination of the values of nth and $(n+1)^{th}$ degree difference of the polynomial of degree n (Theorem with proof).

Unit – II : Finite Difference – II 1 credit (13 lectures)

- Concept of interpolation and extrapolation and their importance, derivation of
- Newton's forward and backward interpolation formula (without remainder terms),
- Construction of divided difference table and its properties, Newton's divided difference interpolation formula and Lagrange's interpolation formula for unequal intervals (without remainder terms)
- Central difference formulae : Gauss and Stirlingi formulae.

Unit –III : Finite Difference – III 1 credit (13 lectures)

Inverse interpolation : Lagrange's inverse interpolation formula, Method of successive approximation and method of reversion of series Stirling's bivariate interpolation. Finding root of an Equation: Bisection, Regula Falsi and Newton Raphson Methods. Numerical differentiation.

Unit – IV : Finite Difference – IV 1 credit (13 lectures)

Numerical integration: Newton-Cote's integration formula, Trapezoidal rule, Simpson's one-third rule, Simpson's three-eight rule and Weddle's rule with error term, Euler-Maclaurin's summation formula. Stirling's approximation to factorial n.Laplau- Errerette Solution of difference equation with constant

coefficients (homogeneous, non-homogeneous equations only)

Recommended Books:

1. Bradie,B.(2006). A friendly introduction to Numerical Analysis, Pearson Education, India.
2. Gerald,C.F.and Wheatly,P.O.(2005).Applied Numerical Analysis, Pearson Education, India.
3. Hilderbrand,F.B.(1987).Introduction to Numerical Analysis, Second Edition, Dover Publications.
4. Jain,M.K.,Iyengar,S.R.K.andJain,R.K.(2007).Numerical Methods for Scientific and Engineering Computation, Second Edition, Wiley Eastern Ltd.
5. Krishnamoorthy,E.V.and Sen,S.K.(2001).Numerical Algorithms:computations in Science and Engineering. East West Press, NewDelhi.
6. Sastry,S.S.(2000).Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Delhi.
7. Saxena,H.C.(2005).Finite Differences and Numerical Analysis, 15th Revised Edn. (Reprint). S. Chand &Co.
8. Scarborough,J.B.(1966).Numerical Mathematical Analysis, 6th Edition. Oxfordand IBH.

STC204P: Practical based on STC208T, STC209T& STC210T 6 credits

Learning Outcomes:

The students shall be

(a) able to use demonstrate knowledge of differen numerical methods, essential for providing Mathematical support to the Statisticians where intractability becomes severe,

(b) be able to forcast numerical phenomenon, using Bisection, Newton Raphson, Regula Falsi Methods,

(c) be able to find solutions to difference equations of first order and linear difference equations with constant coefficients and apply regression techniques, obtain UMP tests and demonstrate knowledge of numerical methods.

List of the practicals:

1. Calculation of coefficient of correlation.
2. Calculation spearman rank correlation
3. Simple linear regression, residuals, estimate of intercept, regression coefficients.
4. Residual plots, regressiondiagnostics.
5. Multiple linear regression and regression estimates.
6. Calculation of multiple correlation,
7. Calculation of partial correlation.
8. Polynomial regression and regressionestimates.
9. Calculation of Type I and Type II errorprobabilities.
10. Calculation of size of critical region, power of the test for the mean of a normal distribution with known and unknown variance and plotting graph of the power function.
11. Calculation of size of most powerful critical region (NPlemma).
12. Evaluating shortes tconfidence interval for mean of normal distribution when variance is known/unknown.
13. Evaluating shortest confidence interval for variance of normal distribution when mean isknown/unknown.
14. Calculation of power of the test for the Bernoulli distribution with probability (p) in case of simple hypothesis and power curves and plotting the graph of the power function.
15. Calculation of likelihood ratio test (LRT) for simple hypothesis.

16. Calculation of likelihood ratio test(LRT) for composite hypothesis.
17. Calculation of asymptotic properties ofLRT.
18. Sequential probability ratiotest for the given hypothesis, esp. For Bernoulli trails. Calculation of ASN and OCcurve.
19. Newton's forward,backward and divided difference interpolation formulae with errorterm.
20. Lagrange's interpolation formula, Central difference formulae.
21. Lagrange's inverseinterpolation.
22. Trapezoidalrule,Simpson'sone–third rule and Simpson's three-eighth rule.
23. Weddle's rule with errorterm.
24. Stirling's approximation to factorialn.
25. Euler-Maclaurin's summation formula.
26. Solution of difference equations of first order with variable coefficients and linear difference equations with constant coefficients.

STC311T :Optimisation Techniques: 4 credits

Learning Outcomes:

The students shall get exposed to

(a) Graphical and simplex method of solving linear programming problem(LPP)for finding degenerate, unbounded, alternate and infeasible solutions,

(b) post-optimality:addition of constraints, change in requirement vector, addition of new activity and change in costvector,

(c) use of duality to solve aLPP,

(d) obtaining solution of a transportation problem by North West corner method, Matrix Minima method, Vogel'smethod,

(e) Hungarian Method for solving assignment problems,

(f) Game theory for graphical solution of mx2 or 2xn rectangular game and mixed strategy,

(g) Networking problem using minimal spanning tree and shortest route,

(h) optimal inventory policy for EOQ model and its variations.

(i) solving quantity discounts model with pricebreaks.

Unit –I : Operation Research –I 1 credit (13 lectures)

Origin and development of OR, importance and scope of OR

- Models of OR – iconic analogue and mathematical models – their construction and general method of solution
- Elements of LPP canonical and standard forms formulation of IPP
- Solution of LPP by graphical method (for 2 variables).

Unit –II : Operation Research –II 1 credit (13 lectures)

- Solution of LPP by simplex method
- Artificial variable, solution of LPP by Big-M method
- Concept Principle and formulation of dual problem, statement and proof of duality theorem
- Dual simplex method, simple problems based on duality theorem.

Unit –III : Operation Research –III 1 credit (13 lectures)

Allocation Models: Transportation problem (T.P.), different methods of finding initial feasible solution of a T.P., UV method of finding optimal solution of a T.P., solution of assignment problem using Hungarian method.

Unit –IV : Operation Research –IV 1 credit (13 lectures)

Inventory Control: Definitions of various costs involved in inventory control. ABC inventory

system, characteristics of inventory system.

Theory of games: Two person zero-sum games, pure and mixed strategies, saddle point, minimax-Maximin principle of rectangular games, games with and without saddle point.

Recommended Books:

1. Gass,S.I.(2010).Linear Programming, Methods and Applications, 5th Ed.,Dover Books.
2. Hadley, G. (2002). Linear programming.Narosa.
3. Hiller,F.S.and Liebermann,G.J.(2009).Introduction to Operations Research, McGrawHill.
4. McKinsey,J.C.C.(2003).Introduction to the Theory and Games. Dover Books.
5. Swaroop,K.,Gupta,P.K. and Singh, M.M.(2005).Operations Research. Sultan Chand andSons.
6. Taha,H.A.(2014).Operations Research, Ninth Edition, Pearson Education India.

STC312T: Statistical Quality Control and Reliability 4 credits

Learning Outcomes:

The students will be able to

(a) construct group control chart,
(b) draw charts for variables and attributes,
(c) draw CUMSUM chart,
(d) understand single and double sampling inspection plans, OC and ASN functions,
(e) get introduced to notion of censored data, Type II and random censoring schemes,
(f) get idean of important lifetime distributions such as for exponential, Weibull, gamma and lognormal distributions.
(g) compute MLEs of exponential distribution for complete and censored data,
(h) compute MLEs of lognormal distributions,
(i) compute MLEs of gamma and Weibull distributions using iterative procedure,
(j) fit exponential and Weibull distributions for a given lifetime dataset,
(k) find interval estimates for the parameters of exponential, Weibull, gamma and lognormal distributions.
(l) Test reliability hypotheses for exponential and Weibull distributions,
(m) Evaluate system reliability for series, parallel, k out of n systems,

Contents:

Unit –I : Quality Control 1 credit (13 lectures)

Introduction to SQC. Quality of a product, need for quality control, basic concept of process control, process capability and product control, general theory of control charts, causes of variation in quality, control limits, sub grouping summary of out of control criteria. Charts for attributes: p chart, np chart, c-chart, V chart. Charts for variables: R, (x, R), (x, o) charts.

Unit –II : Reliability –I 1 credit (13 lectures)

Single and double sampling inspection plans, OC and ASN functions.
Life testing and reliability theory : Basic concepts of life testing experiments, reliability, hazard function, mean time to failure and their relationships. Elementary notion of censored data, type I, type II and random censoring schemes, Poisson process.

Unit –III : Reliability –II 1 credit (13 lectures)

-Parametric distributions: exponential, Weibull, gamma, and lognormal as life time distributions,
-point andinterval estimation procedures for the above distributions.
-Testing reliability hypothesis for exponential andWeibull distributions.
-concept of system reliability.

Unit – IV : Psychological & Educational Statistics 1 credit (13 lectures)

- Scale, characteristics of a scale, Assumptions in scaling
- Scaling of test items : Scaling individual test items in terms of difficulty, difficulty value of a test items and problems based on this.
- Scaling of scores on a test score, raw score, scaled score, standard scores, normalized scores, T-scores, percentile scores and problems based on them.
- Scaling of rankings and ratings in terms of normal probability curve,
- Reliability of test scores: Concept of reliability, Linear model of modern test theory and its components and assumption, index of reliability, parallel test.
- Methods of determining test reliability : Test-relist, alternate or parallel form, split-half and Rational equivalence or Kuder-Rechardson.
- Test length on reliability : Spearman – Brown prophecy formula to determine reliability for a given test length, lengthening a test to achieve a certain desired reliability
- Validity: Concept of validity of test scores, validity and test length, lengthening needed to achieve given validity.
- Intellegence Quotient (IQ) : IQ in terms of mental and chronological ages, classification of individuals based on IQ level according to StandforBinet 5th edition classification, Terman classification and Merrill classification (only classification tables).
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Recommended Books:

- Banks,J.(1989).Principles of Quality Control. John Wiley & Sons, New York.
- Barlow,R.E.andProschan,F.(1974).Statistical Theory of Reliability and Life Testing Probability Models, Holt Rinehart andWinston.
- Duncan,A.J.(1974).QualityControl and Industrial Statistics, 4th Edition, Taraporewala&Sons.
- Montgomery, D.C. (2012). Introduction to the Statistical Quality Control, 7nd Edition, John Wiley &Sons.
- Schilling,E.G.andOtt,E.R.(1975).Process Quality Control. McGrawHill.

STC305P: Practical based on STC311T& STC312T 4 credits

List of Practicals

1. LPP by graphical, simplex methods and dual method (6 Practicals)
2. LPP in Big-M method (3 Practicals)
3. Construction of control charts: Control charts for variable and attributes (3+4 practicals)
4. T – Score & Percentile score (1+1 =2 practicals)

Recommended Books: Same to Recommended Books of STC311T& STC312T

Learning Outcomes:

This course is based on **STC311T& STC312T** and at the end of the course, students shall be able to draw different types of control charts for variables and attributes. They will also be able to understand the practical applicability of single and double sampling inspection plans.

The students will be able to get an idea of reliability and hazard function and how to discriminate among the important lifetime distributions based on hazard function.

Learning outcomes of this course are similar to those of ST-C-15 and ST-C-16.

List of practicals:

1. Construction of group controlchart.
2. Draw an R chart and a modified Rchart.
3. CUMSUMchart.
4. Computation of MLE of exponential, lognormal distributions.

5. Computation of MLE of exponential distribution for censored data.
6. Computation of MLE of Gamma and Weibull distributions using iterative procedure.
7. Fitting of Exponential and Weibull distributions foragiven lifetime data set.
8. Plotting of Survival function and hazard rate function for exponential, Weibull, Gamma and lognormal distributions.
9. Graphical and simplex method of solving linear programming problem (LPP) for degenerate solution, unbounded solution, alternate solution and infeasible solution.
10. Post-optimality:addition of constraints, change in requirement vector, addition of new activity and change in costvector.
11. Obtaining solution of LPP using simplex method. Use of duality to solvea LPP.
12. Obtaining solution of a transportation problem by Northwest corner method, Matrix Minima method, Vogel'smethod.
13. Practical based on assignmentproblems.
14. Practical based on gametheory:graphical solution of mX2 or2Xn rectangular game, mixed strategy.
15. Networking problem: minimal spanning tree problem, shortest route problem.
16. To find optimal inventory policy for EOQ model and its variations.

Recommended Books: Same to Recommended books of STC311T& STC312T

STC313T: Design of Experiments **4 credits**

Learning Outcomes :

The students will be in a position to

(a) carry out one way and two way Analysis of Variance (ANOVA).
(b) understand the basic terms used in design of experiments,
(c) use appropriate experimental designs to analyze the experimental data, 2^2, 2^3, & 2^4 factorial experiments.
(d) analyze : 2^2, 2^3 and 2^4 factorial experiments,
(e) apply Multiple range test, the LSD test or the multiple t-test, Student-Newman-Keuls test, Duncan's multiple range test, Tukey;s test, Multiple F tests, Fisher's least significant difference test, Scheffe's tests,
(f) give statistical interpretation of the experimental results obtained.

Contents:

Unit I : Analysis of Variance **1 credit (13 lectures)**

Analysis of variance: Definition, assumption for ANOVA test, one-way and two-way classifications forfixed effect model with one observation per cell. Introduction to design of experiments: terminology, experiments, treatment, experimental units, blocks, experimental error, replication, precision and accuracy, need for design of experiment, size and shape of plots and blocks.

Unit –II :Some Designs of Experiments **1 credit (13 lectures)**

Fundamental principles of design of experiments: Randomization, Replication and Local control, Completely randomized design (CRD), Randomized Complete Block Design(RCBD), Latin square design(LSD) and their layout and analyses. Missing plot technique for RCBD and LSD : missing plot techniques for one and two observation per cell in RCBD and one observation per cell in LSD. Analysis of covariance in CRD and RCBD with one concomitant variable: concepts and examples, transformations.

Unit III : Comparision Tests **1 credit (13 lectures)**

Multiple range tests, the LSD test, Student-Newman-Keuls test, Duncan's multiple range test, Tukey's test, comments on multiple range test, Multiple F tests, Fisher's least significant difference test, Scheffe's test, comments on multiple F tests.

Unit IV : Factorial Experiments **1 credit (13 lectures)**

-Factorial experiments: Definition, advantages and limitations, main effects and interaction effects, concepts and analysis of 2^2, 2^3, and 2^4 factorial experiments applied in RBD.

-Yate's procedure for computation of factorial effect totals and their analyses.
-Analysis of 2^2, 2^3 and 2^4 factorial experiments applied in RBD.
-Concept of 3^2 and 3^3 factorial experiment (without analysis)
-Confounding in factorial experiments (Total and partial confounding in 2^2, 2^3 and 2^4,)
-Concept of confounding in 3^2 and 3^3 factorial experiment (layout only)
Split plot technique applied in RBD (without analysis)
-Description of strip plot arrangement in RBD (without analysis)
-Series of experiment (without analysis).

Recommended Books:

1. Cochran,W.G.andCox,G.M.(1957).ExperimentalDesign.JohnWiley&Sons, NewYork.
2. Das, M. N. and Giri, N. S. (1986). Design and Analysis of Experiments (2nd Edition). Wiley.
3. Dean,A.andVoss,D.(1999).Design and Analysis of Experiments. Springer-Verlag, NewYork.
4. Federer,W.T.(1955).Experimental Design:Theory and Applications. Oxford&IBH Publishing Company, Calcutta, Bombay and NewDelhi.
5. Joshi,D.D.(1987).Linear Estimation and Design of Experiments. New Age International (P) Ltd. NewDelhi.
6. Montgomery,D.C.(2017).Design and analysis of Experiments,9th Edition.John Wiley & Sons.

STC314T: Non-Parametric Inference 4 credits

Learning Outcomes:
This course will help the students to
(a) use different non-parametric/distribution-free tests when data don't meet the assumptions of parametric test,
(b) understand importance of different non-parametric test procedures, their applications and interpretation,
(c) analyse categorical data using logistic regression models.

Contents:

Unit I : One Sample Tests 1 credit (13 lectures)
Introduction, concepts of non-parametric/distribution free method: one-sample case: Binomial test, Chi-Square Goodnes –of-fit test, Kolmogorov-Smirnov one sample test, One-sample runs test for randomness, sign test, Wilcoxon's signed rank test, theory and applications.

Unit II : Two Sample Tests 1 credit (13 lectures)
Two-sample case: median test, Wilcoxon-Mann-Whitney test, Mood test, Freund-Ansari test, Kolmogorov-Smirnov two-sample stes, Siegel-Tukey test for scale differences, theory & applications.

Unit III : Multi-Sample Tests. 1 credit (13 lectures)
The Cochran Q test for K related samples: Friedman test by ranks, extended median test, Kruskal-Wallis one-way analysis of variance by rands, Jonckheere test for ordered alternatives Theory and applications of these tests.

Unit IV : Categorical Data Analysis 1 credit (13 lectures)
Concept of Indicator Variables, categorical data analysis, logistic regression models, models with binary response. Theory and Applications.

Recommended Books :

1. Gibbons,J.D.andChakraborty,S.(2010).Nonparametric Statistical Inference, Chapman and Hall/CRC.
2. Kloke,J.andMcKean,J.W.(2014).Nonparametric Statistical Methods Using R. Chapman & Hall/CRCPress.

3. Neuhäuser,M.(2017).Nonparametric Statistical Tests. AComputational Approach, Chapman and Hall/CRC.
4. Rajagopalan,M.and Dhanavanthan,P.(2012):Statistical Inference. PHIL earning Pvt. Ltd., NewDelhi.
5. Sheskin,D.J.(2011).Handbook of Parametric and Nonparametric Statistical procedure. (Fifth Edition), Chapman and Hall/CRC.
6. Siegel,S,J.and Castellan,N.Jr.(1998).Nonparametric Statistics for the Behavioral Sciences.McGraw-Hill.
7. Sprent,P.and Smeeton,N.C.(2007).Applied Nonparametric Statistical Methods, Chapman & Hall/CRCPress.
8. Wayne, W. D. (2000). Applied Nonparametric Statistics, 2nd Edition. Cengage Learning.

STC306P : Practical based on STC313T and STC314T 4 credits

Learning Outcomes:

The student shall be able to analyse data using various non-parametric tests. Also, the students will be in a position to visualize the scope of experimental designs in getting valid and efficient results. As a result, they will decide to select an appropriate experimental design and analyse the same to interpret the results so obtained.

List of Practicals

ANOVA for one-way & two way classifications (2 Practicals)
CRD, RBD, LSD (3 Practicals)
Missing plot techniques for RBD and LSD (3 Practicals)
Factorial experiments – 2^2, 2^3 and 2^4 Factorial experiments applied in RBD (3 Practicals)

Confounding in Factorial experiments (total and partial) in 2^2,2^3, and 2^4 experiment (3 Practicals)

Non-parametric tests: (i) One sample test, Binomial test, Chi-square goodness of fit test, Kolmogorov – Smirnov test, run test for randomness, sign test, Wilcoxons Signed Rank Test, etc. (6 Practicals)
Two-Sample Case – Median test, Wilcoxon-Mann-Whitney U-test, Mood test, Freund- Ansari test, two-sample test, Siegel-Tukey test for scale differences (5 Practicals)

Recommended Books :

1. Cochran,W.G.and Cox,G.M.(1957).Experimental Design. JohnWiley&Sons, NewYork.
2. Das, M. N. and Giri, N. S. (1986). Design and Analysis of Experiments (2nd Edition). Wiley.
3. Federer,W.T.(1955).Experimental Design:Theory and Applications.Oxford&IBH Publishing Company, Calcutta, Bombay and NewDelhi.
4. Montgomery,D.C.(2017).Design and analysis of Experiments, 9th Edition.John Wiley & Sons.
5. Gibbons,J.D.and Chakraborty,S.(2010).Nonparametric Statistical Inference, Chapman and Hall/CRC.
6. Sheskin,D.J.(2011).Handbook of Parametric and Nonparametric Statistical procedure. (Fifth Edition), Chapman and Hall/CRC.
7. Siegel,S,J. and Castellan,N.Jr.(1998).Nonparametric Statistics for the Behavioral Sciences.McGraw-Hill.
8. Wayne, W. D. (2000). Applied Nonparametric Statistics, 2nd Edition. Cengage Learning.

STC415T :Real analysis & Measure Theory I 4 credits

Learning Outcomes:

Students will acquirespecific knowledge on

- Real number system, fields of numbers,
- Metric space, sequences and series,
- Continuity and differentiability of functions.
- Limits of Sequences of sets,
- Fields and sigma fields,
- Measures and properties, measurable functions and
- Integrability of measurable functions.
- Probability distributions, moments, Characteristics functions and Convergence of random variables

Unit I:Metric space **1 credit (13 lectures)**

Metric space, limit point, isolated point, interior point, open, closed, and compact sets in metric spaces and their relationship; relative open, relative closed, and relative compact sets in metric spaces and their relationship; sequences of sets and their their different conditions; k-dimensional Euclidean spaces; Bolzano-Weirstrass (only statement) and Heine-Borel theorems;

Unit II:Series **1 credit (13 lectures)**

Convergence of sequences, theorems on convergence of addition, subtraction, multiplication and division. Cauchy criteria of convergence of sequence, Subsequences, Subsequential limits, closedness of set of all subsequential limits, Cauchy sequence, limit infimum, suprimum of sequence. convergence of series, their relationship, Cauchy's thin series criterion on convergence, convergence series, uniform convergence, Cauchy condensation of convergence, limit of general exponential series e^x, irrational e.

Unit III:**Function-behavior** **1 credit (13 lectures)**

Right continuity, left continuity and uniform continuity; continuity and compactness; types of discontinuities, differentiability, maxima and minima; Rolle's theorem, Mean value theorem, L'Hospital's rule, Taylor's theorem, total and partial derivatives of functions of many variables. Jacobians of transformations

Unit IV: **Measure-I** **1 credit (13 lectures)**

Limits of sequences of sets, fields and sigma-fields, Borel sets in R^1, Measures and their elementary properties, continuity of finite measures, outer measures, extension theorem(discussion without proof), completion, Lebesgue sets and measures.

Books recommended:

1. W. Rudin (2000),Principles of Mathematical Analysis, McGraw Hills 3rd Edition.

2. R.G. Bartlet - Elements of Real Analysis

3. T.M. Apostole - Mathematical Analysis, Naorosa Publishing

4. Bhat B.R. (1998) - Modern Probability theory, Wiley Eastern

5. B.M. Singh (2003) - Measure, Probability and Stochastic Processes, South Asian Publishers, New Delhi

6. M. Loeve - Probability Theory, Van Nosttrand

7. P.R. Halmos - Measure Theory, Van Nosttrand

8. V.K. Rohatgi(2000) -An Introduction to probability theory and applications, WileyEastern.

STC416T :Linear Algebra, Matrices-II&Statistical Inference-III **4 credits**

Learning Outcomes:

Students will acquire knowledge on

- Vector spaces, linear transformation and projections,
- Matrix algebra and determinants of matrices,
- Characteristics polynomials and solution of system of linear equations.
- Basic elements of decision theory, Randomized and non-randomized decision functions
- Bayesian analysis
- Minimax analysis, solving statistical games, two person zero sum game.

Unit I:Linear Algebra 1 credit (13 lectures)

Vector spaces over fields of scalars, linear independence of vectors, dimension and bases for finite dimensional vector spaces, orthogonality of vectors and subspaces, Gram – Schmidth theorem, linear transformations and projections and their representations by matrices.

Unit II:Matrices I 1 credit (13 lectures)

Row, column spaces of matrix, of product matrix and their dimensions; row, column rank and rank of a matrix, theorems on row, column rank and rank of a matrix; relationship among columns numbers, rows numbers and rank; Sylvester Theorem, Characteristics polynomials of a square matrix, latent roots, vectors and their calculations, relation between algebraic and geometric roots; Cayley-Hamilton theorem, similarity and diagonalization of square matrices,.

Unit III:Matrices II 1 credit (13 lectures)

System of homogeneous linear equations, System of non-homogeneous linear equations, their basic solutions. Necessary and sufficient conditions for their consistency; minimal polynomial of a square matrix, relation between latent roots and determinant of a square matrix, quadratic forms and their value classes, canonical reductions of quadratic forms, simultaneous reducibility of quadratic forms. Spectral decomposition of a matrix involving latent roots and vectors.

Unit IV: Decision Theory II 1 credit (13 lectures)

Minimax analysis, games involving two persons, minimax, Bayes and equalizer strategies, games with finite parametric space, two person zero sum game. Minimax theorem (statement only), general technique for solving statistical games and determination of minimax rules, complete and essentially complete classes, essential completeness of class of all non-randomized decision rules. The complete class theorem.

Recommended Books :

1. S. Lang Linear Algebra,
2. B.M. Singh(2007), An Introduction to Linear Algebra, (South Asian Publishers),
3. S.R. Searle, Matrix Algebra Useful for Statistics, John Wiley

STC407P: Practical based on STC415T & STC416T 4 credits

Learning Outcomes:

Students will be able to find

(1) a basis of a vector space and its corresponding orthonormal vector
(2) orthonormal projection of vector to another vector of same component,
(3) orthonormal projection of vector to a vector space of same component,
(4) characteristic roots and characteristic vectors of matrix,
(5) spectral decomposition of matrix,
(6)Characteristics polynomials and solution of system of linear equations,
(7) Basic elements of decision theory, Randomized and non-randomized decision functions
(8) Bayesian analysis
(9) Minimax analysis, solving statistical games, two person zero sum game.

List of practicals:

1) -Determination of admissible decision rule
2) -Finding of Bayes action
3) -Finding of minimax solution
4) -Finding of Bayes decision rule with given prior distribution
5) -Construction of posterior distribution
6) -Finding of Bayes estimator
7) -Determination of maximin and minimax strategies
8) a basis of a vector space and its corresponding orthonormal vector
9) orthonormal projection of vector to another vector

10) orthonormal projection of vector to a vector space

11) independent solutions of a system of linear homogenous equations

12) independent solutions of a system of linear non-homogenous equations

13) diagonalization of square matrices

14) verification of $\text{rank}(A+B) \leq \text{rank}(A) + \text{rank}(B)$

15) verification of Sylvester theorem

16) equivalent matrices

17) Square matrices

STC417T: Measure Theory II & Statistical Inference IV 4 credits

Learning Outcomes:
Students will acquire knowledge on

- Limits of Sequences of sets,
- Fields and sigma fields,
- Measures and properties, measurable functions and
- Integrability of measurable functions.
- Methods of Point estimation, Large sample properties, sequential analysis with Wald's SPRT.
- Non-parametric Inference, mean and median tests with goodness of fit problems.
- Hypothesis testing, N-P Lemma, UMP tests ,unbiased and similar tests.

Unit I: Measure Theory II 1 credit (13 lectures)

Measurable functions, measurability theorem, measurability of indicators, measurable functions as the limit of sequences of simple functions; integrability, definite and indefinite integrals of simple functions, non-negative measurable functions and general measurable functions, monotone convergence and dominated convergence theorems.,

Unit II: Measure Theory III 1 credit (13 lectures)
Integration, integrability, definite and indefinite integrals of simple functions, non-negative measurable functions and general measurable functions, monotone convergence and dominated convergence theorems.,

Unit III: Non-parametric 1 credit (13 lectures)
Non-parametric tests, single sample location, location cum symmetry, randomness and goodness of fit problems; U – statistic and properties, Kolmogorov test and its consistency, location problem- sign test, and its optimality, Wilcoxon sign rank test & its consistency, two sample problem- Kolmogorov – Smirnov test, run test, Wilcoxon-Mann-Whitney test, median test, consistency and asymptotic normality.

Unit IV: Statistical Inference IV 1 credit (13 lectures)
Randomized tests and critical functions, N-P lemma for best test, Bayes and minimax rests, MLR families of distributions, UMP tests, unbiased tests, UMP unbiased tests, similar tests, locally best tests, tests with Neyman structure, UMP tests for K-parameter exponential family.

Books recommended:

1. C.R Rao(1987), Linear Statistical Inference and its Applications, Wiley Eastern
2. Wald, Sequential Analysis, John Wiley
3. E.L. Lehman, Theory of Point Estimation, John Wiley

4. J.G. Gibbons, Non-parametric Statistical Inference, Marcel Dekker
5. B.M. Singh(2003), Measure, Probability and Stochastic Processes, South Asian, Publishers, New Delhi.

STC418T: Linear models, Sum of Squares, Regression III &Sample Survey IV 4 credit

Learning Outcomes:

Students will acquire knowledge on

- Gauss-Markov linear model, estimable functions, BLUE, estimation and error spaces.
- Estimable parametric functions, sums of squares due to estimable linear function(s), linear hypotheses, generalized t and F tests.
- Simple and multiple linear regressions, polynomial fitting, outliers, homogeneity, heteroscedasticity, autocorrelation and multicollinearity,
- Ratio and Regression estimators, Cluster sampling, Two stage sampling, biases and errors

Unit I:Linear models 1 credit (13 lectures)

Linear models – fixed/random effects model, model of full rank/not of full rank with their consequences, estimable parametric functions and their BLUES, use of projections to get best estimates, normal equations, error function and Gauss-Markov theorem, estimation and error space.

Unit II:Sum of Squares 1 credit (13 lectures)

Sum of squares and degrees of freedom due to estimable parametric functions, Linear hypotheses, their tests and S.S. due to them, generalized t and F tests for estimable linear hypotheses and their particular cases with examples, testing a sub-hypotheses, comparison of means – Fisher, Tuckey, Scheffe and Duncan methods.

Unit II:Regression III 1 credit (13 lectures)

Simple linear regression, Multiple regression, methods of fitting, fit of polynomials and use of orthogonal polynomials. Test of fitness of regression models, residuals and their plots as test of departure from normality assumption, detection of outliers, test for homogeneity of variance, departure from Gauss-Markov setup, heteroscedasticity, autocorrelation and multicolinearity.

Unit III: Sample Survey IV 1 credit (13 lectures)

Ratio estimator(in SRS): estimation of the population mean and population total, bias of ratio estimators, approxmimate variance of ratio estimator, advantages and applications of ratio estimators, product estimator (concept only), Regression estimators (in SRS): bias of regression estimator, sampling variance of regression estimator,Non-sampling errors: Source and type, Non-sampling bias, non-response errors.

Recommended Books:

1. D.D. Joshi(2000), Linear Estimation and Design of Experiments, Wiley Eastern
2.A.M. Kshirsagar, A course in Linear Model, Marcel Dekker
3.Drapper and Smith, Applied Regression Analysis, John Wiley & Sons.
4.Hedayat, A. S. and Sinha, B.K. (1991): Design and inference in finite population sampling. Wiley.
5.P.V.Sukhatme, B.V.Sukhatme,S.Sukhatme and C.Asok(1984), Sampling theory of Survey with application, Indian Society of Agricultural Statistics, New Delhi

STC408P: Practical based on STC417T & STC418T 4 credits

Learning Outcomes:

Same to that of STC417T & STC418T

List of practicals:

-Kolmogorov – Smirnov test for goodness of fit.

-Ordinary Sign rank test for single sample.

-Wilcoxon Sign rank test for single sample.

-Kolmogorov- Simrnov test for two Sample.

-Run test for independence of two Samples.

-Wilcoxon Signed test for two Samples

-Median test.

-Most Powerful test for Simple Vs Simple hypotheses of Parameters of Normal distribution.

-Most Powerful test for Simple Vs Simple hypotheses Parameters of Binomial Distribution.

-Most Powerful test for Simple Vs Simple hypotheses Parameters of Poisson distribution.

-UMP unbiased test for mean of normal distribution.

-UMP unbiased test for variance of normal distribution.

-Most powerful test for one tail test (normal, binomial and normal).

-Two sided test for the parameters of normal, binomial and Poisson distributions.

Some practical for regression and sample survey

-Fitting of orthogonal polynomial

- testing of departure from normality assumption,

-detection of outliers,

-testing for homogeneity of variance,

-testing of departure from Gauss-Markov setup, heteroscedasticity, autocorrelation and multicolinearity.

-stimation of ratio

- bias of ratio estimators (in SRS),
- approxmimate variance of ratio estimator,
- Regression estimators (in SRS),
- bias of regression estimator,
- sampling variance of regression estimator

Recommended Books: Same to Recommended Books of STC417T & STC418T

Syllabi of Discipline Specific Electives (DSE)

STD301T: Time Series Analysis **4 Credits**

Learning Outcomes:

This course is meant to acquaint the students with some important but useful concepts on topics in time series analysis so that the students can get an important background material for taking up an advanced course in financial econometrics and data analysis. After completion of this course, the students will know about

(a) Time series data, its applications to various fields and components of time series,

(b) Fitting and plotting of various growth curves such as modified exponential, Gompertz and logistic curve,
(c) fitting of trend by Moving Averagemethod,
(d) measurement of Seasonal Indices by Ratio-to-Trend,Ratio-to-Moving Average and Link Relative methods,
(e) calculation of variance of random component by variate component method,
(f) forecasting by exponential smoothing and shortterm forecasting methods such as Box Jenkins Method and Bayesian forecasting,
(g) weak stationarity, autocorrelation and correlogram,
(h) applications to real data by means of laboratory assignments.

Contents:

Unit I **1 Credits (13 classes)**

Introduction to times series data, application of time series from various fields,Components of a times series, Decomposition of time series.Trend:Estimation of trend by free hand curve method,method of semi averages, fitting a various mathematical curve, and growth curves.

Unit II **1 Credits (13 classes)**

Trend Cont.:Method of moving averages. Detrending.Effect of elimination of trend on other components of the time series. Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio toTrend.

Unit III **1 Credits (13 classes)**

Seasonal Component count: Ratio to Moving Averages and Link Relative method, Deseasonalization. Cyclic Component: Harmonic Analysis. Some Special Processes: Moving-average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2) – Yule-Walker equations.

Unit IV **1 Credits (13 classes)**

Random Component: Variate component method. Forecasting: Exponential smoothing methods, Short term forecasting methods: Brown's discounted regression, Box-Jenkins methodandBayesianforecasting.StationaryTimeseries:Weakstationarity,autocorrelation function and correlogram of movingaverage.

STD301P: Practical based on STD301T **2 credits**

List of practicals:

1. Fitting and plotting of modified exponentialcurve.
2. Fitting and plotting of Gompertzcurve.
3. Fitting and plotting of logisticcurve.
4. Fitting of trend by Moving Averagemethod.
5. Measurement of Seasonal Indices Ratio-to-Trendmethod.
6. Measurement of Seasonal Indices Ratio-to-Moving Averagemethod.
7. Measurement of seasonal indices Link Relativemethod.
8. Calculationofvarianceofrandomcomponentbyvariatedifferencemethod.
9. Forecasting by exponentialsmoothing.
10. Forecasting by short term forecastingmethods.

Recommended Books :

1. Box,G.E.P.,Jenkins,G.M.,Reinsel,G.C.andLjung,G.M.(2015).Time Series Analysis: Forecasting and Control.5th Edition. JohnWiley&sons,Inc.
2. Brockwell,P.J.and Davis,R.A.(2003).Introduction to Time Series Analysis.Springer.
3. Chatfield, C. (2001). Time Series Forecasting., Chapman &Hall.
4. Fuller, W.A. (1996). Introduction to Time Series. 2nd Edition.Wiley.
5. Kendall,M.G.and Ord,J.K.(1990).Time Series.3rd edition.Edward Arnold.
6. Montgomery,D.C.,Jennings,C.L.and Kulahci,M.(2012).Introduction to Time Series Analysis and Forecasting, JohnWiley.
7. Mukhopadhyay,P.(2011).Applied Statistics,2nd ed.Revised reprint, Books and Allied Pvt.Ltd.

STD302T: Applied Statistics **4 Credits**

Learning Outcomes:

After going through this course, the students will have an idea of

(a) income distributions and their fitting in real lifesituations,

(b) commonly used measures of demography pertaining to its three basic aspects,viz. the fertility, mortality andmigration,

(c) various data collection methods enabling them to have a better in sight in policy making, planning and systematic implementation,

(d) Construction and implication of lifetables,

(e) Population growth curves, population estimates andprojections,

(f) Real data implementation of various demographic concepts as outlined above through practical assignments.

Contents

Unit I 1 Credits (13 classes)

Analysis of income and allied size distributions: Pareto and log-normal distributions, genesis, specification and estimation, Lorenz curve, Gini coefficient.
Demand analysis: Classification of commodities, Engelcurve analysis using cross-section and time series data, Engel curves incorporating household characteristics, demand projection, specific concentration curves.

Unit II 1 Credits (13 classes)

Sources of demographic data, census, registration, ad hoc surveys, hospital records, demographic profiles of the Indian census.
Measurement of Mortality and Life Table: Crude death rate, Standardized death rates, Age- specific death rates, Infant Mortality rate, Death rate by cause, Complete life table and its main features, Uses of life table.

Unit III 1 Credits (13 classes)

Measurement of Fertility: Crude birth rate, general fertility rate, age specific birth rate, total fertility rate, gross reproduction rate, net reproduction rate. Rates and ratios. Measures of mortality. Life Table – construction and applications.

Unit IV **1 Credits (13 classes)**

Stable and stationary population. Measures of fertility and reproduction. Indian data.

Standardization of vital rates. Population growth curves, population estimates and projections.

Measures of migration. Use of demographic data for policy formulation.

STD302P: Practical based on STD302T: 2 credits

List of practicals:

1. Fitting of Engel's curve and calculation of income elasticity of demand.
2. Fitting of Pareto's law for income distribution for a given Income data set,for entire range as well as specificrange.
3. Fitting of a Lorentz curve for a data and computation of the concentration ratio using graphicalmethod.
4. Calculation of Crude birth rate; Generalfertilityrate; Age specific fertility rate;Total fertility rate; Gross reproduction rate; Net reproduction rate.
5. CalculationofInfantmortalityrate, Crude death rate, Age specific death rates.
6. Computation of standardized birth and deathrates.
7. Construction of lifetables.
8. Population growth curves, population estimates and projections.

Recommended Books :

1. Benjamin,B.(1959).Health and Vital Statistics. Allen and Unuwin.
2. Cramer,J.S.(1969).Empirical Econometrics. NorthHolland Pub .Co.
3. Karmel,P.H.and Polasek,M.(1957).Statistics for Economists. Pitman Publishing.
4. Klein, L.R. (1962). An Introduction to Econometrics. Prentice Hall.
5. Mishra,B.D.(2004).An Introduction to the Study of Population. South Asian Publishers.
6. Mukhopadhyay,P.(1994).Applied Statistics. New Central Book Agency Pvt. Ltd. Calcutta.
7. Ramkumar, R. (1986). Technical Demography. John Wiley &Sons.
8. Srinivasan,K.(1998).Demographic Techniques and Applications. Sage Publications.
9. Srivastava O.S.(1983).AText Book of Demography.Vikas Publishing House.
10. Shryock,H.S.(1971).The Methods and Materials in Demography. U.S.Bureau of Census.

STD403T: Survival Analysis 4 Credits

Learning Outcomes:

The course gives the application of statistics in handling survival data.The students will know about concepts of

(a) Type-I (time), Type-II (order) and random censoring,

(b) Survival Function, Failurerate, meanresiduallife,TotaltimeonTest,

(c) Applications of exponential,gamma,Weibull distributions, lognormal, Pareto,linear failure rate distributions to lifetime data,

(d) Ageing properties of IFR,IFRA,DMRL,NBU,NBUE and HNBUE and Dualclasses.

(e) Actuarial and Kaplan –Meier estimator of survivalfunction,

(f) Cox's proportional hazards and competing riskmodels,

(g) tests forexponentiality,

(h) Real lifetime data implementation of various concepts as outlined above through practical assignments.

Contents

Unit I 1 Credits (13 classes)

Concepts of Type-I (time), Type-II (order) and random censoring, Survival Function, Failure rate, mean residual life and their elementary properties. Total time on Test, bathtub failure rate.

Life distributions: exponential, gamma, Weibull, lognormal, Pareto, linear failure rate.

Unit II 1 Credits (13 classes)

Ageing classes(IFR,IFRA,DMRL,NBU,NBUE and HNBUE) and their properties, Dual classes, Interrelations between different ageingclasses.

Unit III 1 Credits (13 classes)

Estimation of survival function – Actuarial estimator, Kaplan –Meier estimator, Cox's proportional hazards model, competing risks model.

Unit IV 1 Credits (13 classes)

Definition of U statistics, tests for exponentiality versus positive ageing class such as IFR, IFRA,NBU.

STD403P: Practical based on STD303T 2 credits

List of practicals:

1. ExamplesofType-I(time),Type-II(order)andrandomcensoring.
2. Finding Survival Function, Failure rate, mean residual life, Totaltimeon Test.
3. Applications of exponential, gamma, Weibulldistributions.
4. Applications of lognormal, Pareto, linear failure ratedistributions.
5. Problems on ageing properties, IFR, IFRA, DMRL, NBU, NBUE and HNBUE and Dual classes.
6. Examples for Actuarial estimator and Kaplan–Meier estimator of survival function.
7. Applications of Cox's proportional hazardsmodel.
8. Applications of competing risksmodel.
9. Tests forexponentiality.

Recommended Books :

1. Cox,D.R.and Oakes,D.(1984). Analysis of Survival Data. Taylor and Francis.
2. Crowder, M. J.(2001).Classical Competing Risks. Chapman & Hall/CRC Press, London.
3. Deshpande, J. V. and Purohit, S.G. (2015). Lifetime Data: Statistical Models and Methods. 2nd Edition. WorldScientific.
4. Gross,A.J. & Clark,V.A.(1976).Survival Distributions-Reliability Applicationsin Bio- medical Sciences. John Wiley andSons.
5. Hanagal,D.D.(2011).Modeling Survival DataUsing Frailty Models. Chapman & Hall. NewYork.
6. Kalbfleisch, J.D. and Prentice, R.L. (1980). The Statistical Analysis of Failure Time Data. John Wiley and Sons.
7. Miller,R.G.(1998).Survival Analysis. Second Edition.Wiley Interscience.

STD404P: Project (based on sample survey/Design of experiments/Demography/Survival analysis/ etc.) 6 credits

Learning Outcomes: , the students will have an idea of real life situations, will be able to analyse data and interprete it.
Students should submit a research report based on empirical study on some real life situation. The student will personally collect, analyze, interpret the data and prepare are port under the supervision of a faculty.

References:

1. Kothari,C.R.(2009):ResearchMethodology:MethodsandTechniques,2ndRevised Edition reprint, New Age InternationalPublishers.
2. Kumar,R(2011):ResearchMethodology:AStep-by-StepGuideforBeginners, SAGEPublications.

Generic Electives/Interdisciplinary Papers (6 credits each) (Statistics students will opt 6 GE papers offered by other Departments/Disciplines. Students from other Departments/disciplines shall opt for any 6 papers from the following 6 GEcourses.)

STG201T: Introduction to Statistics-I 4 credits (15 Classes)
Learning Outcomes:

This course is designed for students other than statistics discipline and can be opted as choice based credit system (CBCS).This course will make the students conversant with

(a) Various techniques used in summarization, presentation and analysis of ifferent types of Statistical data,

(b) Various summary measures of central tendency, dispersion, moments, skewness and kurtosis.

(c) Simple and rank correlation, Partialand Multiple correlation coefficients.

(d) Fitting of linear and quadratic regressions using principle of leas tsquares.

(e) Measures of association for 2x2 and rxs contingency tables.

(f) have knowledge on theoretical as well as practical approach.

Contents:

Unit I 1 Credits (13 classes)

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Scales of measurement -nominal, ordinal, interval and ratio. Variables and attributes, Diagrammatical Representation of Data, Summarization of Data: Frequency Distribution and Graphical Presentation.

Unit II 1 Credits (13 classes)

- Notion of Central Tendency : Average, characteristics of an ideal average.
- Arithmetic Mean (A.M): Definition, effect of change of origin and scale, combined mean of a number of groups, merits and demerits, its applications.
- Mode: Definition, formula for computation (with derivation), graphical method of Determination of mode, merits and demerits, its applications.
- Median : Definition, formula for computation (with derivation), graphical method of Determination of median, merits and demerits, its applications.
- Empirical relation between mean, median and mode.

Unit III 1 Credits (13 classes)

- Partition Values : Quartiles, Deciles and Percentiles, their applications.
- Geometric Mean (G.M) : Definition, merits and demerits, its applications
- Harmonic Mean (H.M) : Definition, merits and demerits, its applications
- Relation between A.M., G.M., and H.M.
- Weighted Mean : Weighted A.M., G.M., and H.M.
- Box-plot

Unit IV 1 Credits (13 classes)

- Concept of dispersion, characteristics of an ideal measure of dispersion.
- Range : Definition, merits and demerits.
- Semi-interquartile range (Quartile deviation).
- Mean deviation : Definition, merits and demerits,
- Mean square deviation : Definition,

Variance and standard deviation – definition, merits and demerits, effect of change of origin and scale.

- Determination of variance of a combined series.
- Measures of dispersion for comparison : coefficient of range, coefficient of quartile Deviation and coefficient of mean deviation, coefficient of variation (C.V.)

STG201P: Practical based on STG201P 2credits

Contents:

1. Identification of scales of measurement andvariables.
2. Diagrammatical representation of data, Summarization of data: Frequency Distribution and graphicalPresentation.
3. Measures of central tendency: mathematical andpositional.

Calculation of mean, median, mode, range, sem-interquartile range mean deviation, mean square deviation, Variance, standard deviation, coefficient of range, coefficient of quartile

4. Deviation and coefficient of mean deviation, coefficient of variation (C.V.)

Recommended Books:

1. Gun, A.M., Gupta,M.K.and Das gupta,B.(2013). Fundamental of Statistics, VolI , World Press, Kolkata.
2. Gun,A.M.,Gupta,M.K. and Dasgupta,B.(2011). Fundamental of Statistics,Vol II, World Press,Kolkata.
3. Hanagal, D.D.(2009). Introduction to Applied Statistics:ANon-Calculus Based Approach. Narosa Publishing Comp. NewDelhi.
4. Miller,I.and Miller,M.(2006). John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education,Asia.
5. Mood,A.M. Graybill, F.A.andBoes, D.C.(2011).Introduction to the Theory of Statistics, 3rd Edn.,(Indian Edition),Tata Mc Graw-HillPub. Co.Ltd.
6.

STG202T: Introduction to Statistics-II 4 credits

Learning Outcomes:

This course is designed for students othe rthan statistics discipline and can be opted as choice based credit system (CBCS). This course will make the students conversant with

(a) Various summary measures of dispersion, moments, skewness and kurtosis.
(b) Simple and rank correlation, Partialand Multiple correlation coefficients.
(c) Measures of association for 2x2 and rxs contingency tables.
(d) have knowledge on attributes and Chi-square.

Contents:

Unit I **1 Credits (13 classes)**

- Raw moments for grouped and ungrouped data.
- Moments about arbitrary constant for grouped and ungrouped data.
- Central moments for grouped and ungrouped data, Effect of change of origin and Scale, Sheppard's correction for moments upto fourth order(without proof).
- Relations between central moments and raw moments (upto fourth order).
- Karl Pearson's β and √ coefficients

Unit II **1 Credits (13 classes)**

Moments

- Raw moments for grouped and ungrouped data.
- Moments about arbitrary constant for grouped and ungrouped data.
- Central moments for grouped and ungrouped data, Effect of change of origin and Scale, Sheppard's correction for moments upto fourth order(without proof).
- Relations between central moments and raw moments (upto fourth order).
- Karl Pearson's β and √ coefficients

Unit III **1 Credits (13 classes)**

Skewness and Kurtosis

- Concept of skewness of frequency distribution, positive, negative skewness, symmetric

frequency distribution.
- Bowley's coefficient of skewness.
- Karl Pearson's coefficient of skewness
- Measures of skewness based on moments
- Concepts of kurtosis, leptokurtic and platykurtic frequency distributions.
- Measures of kurtosis based on moments

Unit IV **1 Credits (13 classes)**

Bivariatedata: Definition, scatter diagram, simplecorrelation, rank correlation.
Trivariate Data: Partial and Multiple correlation coefficients. Attributes and Chi-square.

STG202P: Practicals based on STG202T **2 credits**

List of practicals:

1. Identification of scales of measurement, variables andattributes.
2. Moments, measures of skewness and kurtosis.
3. Scatter diagram, simple correlation, rankcorrelation.
4. Partial and Multiple correlationcoefficients.
5. Fitting of linear and quadratic regression using principle of least squares.
6. Measures of association for 2x2 and rxs contingency tables
7. Calculation of Chi-square

1. Gun,A.M.,Gupta,M.K.and Dasgupta,B.(2013).Fundamental of Statistics, VolI World Press, Kolkata.
2. Gun,A.M.,Gupta,M.K.and Dasgupta,B.(2011).Fundamental of Statistics, Vol II, World Press,Kolkata.
3. Hanagal, D. D.(2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. NewDelhi.

STG303T: Introduction to Probability Theory **4 credits (15 Classes)**

This course is designed for students other than statistics discipline and can be opted as choice based credit system (CBCS). This course will lay the foundation to probability theory and Statistical modeling of outcomes of real life random experiments through various Statistical distributions.

Learning Outcomes:

The students will get to know about

(a) Writing of sample space, events and algebra of events and finding Probability of events,

(b) Conditiona lProbability and applications of Theorem of total probability and Bayes' theorem,

(c) Discrete and continuous Random Variables, Probability mass function(p.m.f.) and Probability density function(p.d.f.), Cumulative distribution function(c.d.f.)

(d) Expectation, variance, moments and moment generatingfunction.

(e) Problem solving pertaining to binomial, Poisson, geometric, negativebinomial, hyper geometric, uniform, normal, exponential, beta, gamma distributions.

(f) fitting of Binomial, Poisson and Normal distributions

(g) Chebyshev's inequality, Convergence in probability, Weak law of large numbers, Convergence in distribution, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorems(C.L.T.),

(h) Various aspects as outlined above through practica lassignments.

Contents:

Unit I **1 Credits (13 classes)**

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 itsapplications.

Unit II **1 Credits (13 classes)**

Random Variables: Discrete and continuous random variables, Probability mass function (p.m.f.), Probability density function (p.d.f.), Cumulative distribution function (c.d.f.) Illustrations of random variables and their properties. Expectation, variance, moments and moment generating function.

Unit III **1 Credits (13 classes)**

Standardprobabilitydistributions: Binomial, Poisson, geometric, negative binomial, hyper geometric, uniform, normal, exponential, beta, gamma and their applications. Fitting of Binomial, Poisson and NormalDistributions

Unit IV **1 Credits (13 classes)**

Chebyshev'sinequality, Convergence in probability, Weak law of large numbers, Convergence in Distribution, De-MoivreLaplaceandLindeberg-Levy Central Limit Theorems (C.L.T.).

STG303P: Practicals based on STG303T **2 credits**

List of Practicals:

1. Writing sample space, events and algebra ofevents.
2. Finding Probability ofevents.
3. Computing Conditional Probability, Use of laws of addition and multiplication, Problems on independent events, theorem of total probability and applications of Bayes'theorem.
4. Identifying Discrete and continuous Random Variables, writing Probability mass function (p.m.f.) and Probability density function (p.d.f.), Finding Cumulative distribution function(c.d.f.)
5. FindingExpectation, variance, moments and moment generating function.
6. Problem solving pertaining to binomial, Poisson, geometric, negative binomial, hyper geometric, uniform, normal, exponential, beta, gamma distributions.
7. Fitting of Binomial, Poisson and Normaldistributions
8. Problems on Chebyshev's inequality, Convergence in robability, Weak law of large numbers, Convergence in distribution, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorems(C.L.T.).

Recommended Books:

1. Hanagal, D.D. (2009).Introduction to Applied Statistics: ANon-Calculus Based Approach. Narosa Publishing Comp. NewDelhi.
2. Hogg,R.V.,Tanis,E.A.and RaoJ.M.(2009).Probabilityand Statistical Inference, Seventh Ed, Pearson Education, NewDelhi.
3. Meyer, P.L.(1970).Introductory Probability and Statistical Applications, Oxford& IBH Publishing, New Delhi.
4. Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education,Asia.
5. Rohatgi,V.K.and Saleh A.K.M.E.(2008).An Introduction to Probability Theory and Mathematical Statistics, WileyEastern.

STG304T: Introduction to Statistical Inference **4 Credits**

This course is designed for students other than statistics discipline and can be opted as choice based credit system(CBCS).

Learning Outcomes:

The students will get an exposure to

(a) Techniques of estimation and testing of hypotheses for mean,variance,proportions, correlation coefficient, association and goodness offit,
(b) Confidence intervals for the parameters of a normal distribution (oneandtwo-sample problems),
(c) Test of significance for correlation coefficient, Fisher'sz–transformation,
(d) Tests of proportions, tests of association and goodness-of-fitusing Chi-squaretest, Yates'correction,
(e) analysis of variance technique for one andtwo way classifications,
(f) analysis of commonly use dexperimental designs such as CRD, RCBD etc.,
(g) non-parametric tests such as Sign test for median and symmetry, Wilcoxontwo- sample test,
(h) practical applications through laboratory assignments.

Contents:

Unit I — 1 Credits (13 classes)

Estimation of population means, confidence intervals for the parameters of a normal distribution (one and two-sample problems).
The basic idea of significance test, Null and alternative hypothesis. Type I & Type IIerrors, level of significance, concept of p-value. Tests of hypotheses for the parameters of anormal distribution (one and two-sampleproblems).

Unit II — 1 Credits (13 classes)

Test of significance for correlation coefficient. Fisher's z –transformation,

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction.

Unit III — 1 Credits (13 classes)

Analysis of variance, one-way and two-way classifications. Brief exposure of three basic principles of design of experiments, treatment, plot and block. Analysis of completely randomized design, randomized complete block design.

Unit IV — 1 Credits (13 classes)

Basic idea of non-parametric tests, sign test for median, sign test for symmetry, Wilcoxon two-sample test.

STG304P: Practicals based on STG304T

List of practicals:

1. Estimation of populationmeans,
2. Finding confidence intervals for the parameter sof a normal distribution(oneandtwo- sample problems).
3. Tests of hypotheses fo rthe parameters of a normal distribution(one and two-sample problems).
4. Test of significance for correlation, coefficient, Fisher'sz–transformation.
5. Tests of proportions, tests of association and goodness-of-fitusingChi-squaretest, Yates'correction.
6. Analysis of variance (one-way and two-wayclassifications).
7. Sign test for median and sign test forsymmetry.
8. Wilcoxon two-sampletest.

Recommended Books :

1. Chap, T.L. and Eberly, L.E. (2016). Introductory Biostatistics.Wiley.
2. DanielWayneW.andCross,C.L.(2013).Bio-statistics:A foundation for Analysis in the Health Sciences. JohnWiley.
3. Das, M.N. and Giri, N.C.(1986).Design and analysis of experiment, Second Edition. JohnWiley.
4. Dunn, O.J. and ClarkeV.A.(2009).Basic Statistics: APrimer for the Biomedical Sciences, Fourth Edition. JohnWiley.
5. Gun,A.M.,Gupta,M.K.and Dasgupta,B.(2013).Fundamental of Statistics,Vol I. World Press, Kolkata.
6. Gun,A.M.,Gupta,M.K.and Dasgupta,B.(2011).Fundamental of Statistics,Vol II. World Press, Kolkata.
7. Hanagal, D.D. (2009).Introduction to Applied Statistics: ANon-Calculus Based Approach. Narosa Publishing Comp. NewDelhi.
8. Pagano, M. and Gauvreau, K.(2018).Principles of Biostatistics,S econdEdition. Chapman and Hall/CRC.

STG405T: Introduction to Applied Statistics **4 credits (15 classes)**

Learning Outcomes:

This course is designed for students other than statistics discipline and can be opted as choice based credit system (CBCS).
The course will expose the students to

(a) time series, index numbers, qualitycontrol and demographic methods,

(b) different methods of measurements in timeseries

(c) computationofdifferenttypesofindexnumbers,consumerpriceindexnumber,

(d) qualitycontrolchartsforvariablesandattributeshelpfulinindustryformaintaining quality,

(e) measuresoffertilityandmortalityusefulforhelpingthegovt.tomakedecisions,

(f) practical applications of the various concepts outlinedabove.

Contents:

Unit I **1 Credits (13 classes)**

Economic Time Series: Component of time series, Decomposition of time series-Additive and multiplicative models with their merits and demerits, Illustrations of time series. Measurementoftrendbymethodoffree-handcurve.Methodofsemi-averageandmethodof leastsquares(linear,quadraticandmodifiedexponential)Measurementofseasonalvariations by method of ratio totrend.

Unit II **1 Credits (13 classes)**

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

Unit III **1 Credits (13 classes)**

Statistical Quality Control: Importance of statistical methods in industrial research and practice. Determination of tolerance limits. Causes of variations in quality: chance and assignable causes. General theory of control charts, process & product control, control charts for variables: and R-charts. Control charts for attributes: p and ccharts

Unit IV **1 Credits (13 classes)**

Demographic Methods: Introduction to measurement of population, rates and ratios of vital events.Measurement of mortality: Crude Death Rate (CDR), Standardised Death Rate (SDR) (w.r.t. age and sex). Measurement of fertility and reproduction: Crude Birth Rate (CBR), Gross Fertility Rate (GFR) and Total fertility rate (TFR).

Life (mortality) tables: definition of its mainfunctions and uses, Measurement of population growth: Gross Reproduction Rate(GRR),Net Reproduction Rate(NRR).

STG405P: Practicals based on STG405T
List of practicals:

1. Measurement of trend by method of free-hand curve. Method of semi-average and method of least squares (linear, quadratic and modified exponential) Measurement of seasonal variations by method of ratio totrend.
2. Computation of different type so find exnumbers, consumer price index number.
3. X and Rcharts
4. p and c charts
5. Computation of Crude Death Rate (CDR), Standardised Death Rate (SDR) (w.r.t.Age and sex).
6. Computation of Crude Birth Rate (CBR), Gross Fertility Rate (GFR) and Total fertility rate(TFR).
7. Completion of a life table by computing values of different functions.
8. Computation of Gross Reproduction Rate (GRR), Net Reproduction Rate (NRR).

Recommended Books:

1. Gun, A.M., Gupta, M.K. and Dasgupta,B.(2011).Fundamental of Statistics,VolII. World Press, Kolkata.
2. Gupta, S.C.and Kapoor,V.K.(2008).Fundamentals of Applied Statistics. 4th Edition (Reprint), Sultan Chand &Sons.
3. Montgomery, D.C.(2009).Introduction to Statistical Quality Control. 6th Edition, Wiley India Pvt.Ltd.
4. Mukhopadhya, P. (1999).Applied Statistics. New Central Book Agency, Calcutta.

STG406T: Introduction to Operations Research 4 credits (13 classes)

Learning Outcomes:

The students shall get exposed to

(a) Graphical and simplex method of solving linear programming problem(LPP) for finding degenerate, unbounded, alternate and infeasiblesolutions,
(b) use of duality to solve aLPP,
(c) obtaining solution of a transportation problem by North Westcorner method, Matrix Minima method, Vogel's method,
(d) Hungarian Method for solving assignment problems,
(e) gametheory, minimax-maximinrules, graphical solution of mx2 or 2xn rectangular game and mixedstrategy,
(f) net working problem using shortest route.

Contents:

Unit I

Introduction to Operations Research (OR), phases of OR, model building, various types of ORproblems. Linear Programming Problem, Mathematical formulation of the LPP, graphical solutions of aLPP.

Unit II 1 Credits (13 classes)

Optimum solution to a LPP: Simplex method, concept of artificial variables and Charne'sbig M-technique.Graphically identifying special cases of LPP. Concept of duality in LPP.

Unit III **1 Credits (13 classes)**

Transportation Problem: Initial solution by north west corner rule, least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution. Assignment problem: Hungarian method to find optimal assignment.

Unit IV **1 Credits (13 classes)**

Game theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. Networking: Shortest route problem.

STG406T: Practicals based on STG406T

List of practicals:

1. Mathematica lformulation of LPP and solving the problem using graphical method.
2. Simplex technique to solve LPP and reading dual solution from the optimal table.
3. Charne's Big M-method involving artificial variables.
4. Identifying special cases: Degenerate solution, unbounded solution, Alternate solution and infeasible solution by Graphical method and interpretation.
5. Allocation problem using Transportationmodel.
6. Allocation problem using Assignmentmodel.
7. Networking: Shortest routeproblem.
8. Problem based on gamematrix: mx2/2xn Rectangular and Mixed strategies.

Recommended Books:

1. Ravindran, A.Phillips, D.T.and Solberg, J.J. (2005).Operations Research-Principles and Practice. John Wiley & Sons.
2. Swarup, K.Gupta, P.K. and Mohan, M.(2007).Operations Research,13th Edition. Sultan Chand and Sons.
3. Taha,H.A.(2007).Operations Research:An Introduction, 8th Edition. Prentice Hall of India.

Skill Enhancement Courses (4 credits each) (Any 2 papers to be selected)

STS101T: Computational Techniques and R Programming 3 credits

Learning Outcomes:

The students will get acquainted with

(a) Various basic concepts related to computer architecture and its organization, various peripheral devices,

(b) languages:machine language,assembly language and high level languages,

(c) ideas on operating systems, linker, loader and compiler etc.,

(d) R programming with some basic notions for developing their own simple programs and visualizing graphics in R.

Contents:

Unit I **(12 classes)**

Computer basics: Introduction and brief history of evolution of computers, Classification of computers: special purpose and general purpose; analog, digital and hybrid; Super, main-frame etc.

Unit II **(12 classes)**

Organization of general purpose digital computers: CPU, main memory and peripherals. Mass storage devices and other I/Odevices.

Computer languages: Machine code language (machine language), assembly language and high level languages. Software: Operating systems, linker, loader, compiler, interpreter and assembler.

Unit III **(12 classes)**

Computer programming: Algorithm and flow-chart. Storage of information: concepts of records and files. File organization: sequential, relative and indexed.

Unit IV **(12 classes)**

Programming with R: Introduction to R, Data types in R (numeric, logical, character, complex etc.), R objects: vector, matrix, array, list, data frame, factor, and time series. Arithmetic logical and relational operators, explicit and implicit looping, functions and functional programming in R, Lexical scoping rules in R, benefits of Lexical scoping, other scoping rules, debugging facility in R. Few important mathematical, statistical and graphical functions in R.

STS101P: Practicals are based on the topics of the theory mentioned above. 1 Credit

Recommended books:

1. Chambers,J.(2008).SoftwareforDataAnalysis:ProgrammingwithR,Springer.
2. Crawley, M.J. (2017). The R Book, John Wiley &Sons.
3. Eckhouse,R.H.and Morris,L.R.(1975).Minicomputer Systems Organization, Programming and Applications, Prentice-Hall.
4. Matloff, N.(2011).The Art of R Programming, No Starch Press, Inc.
5. Peter, N. (1986). Inside the IBM PC, Prentice-Hall Press.

STS102T: Statistical Techniques for Research Methods 3 credits

Learning Outcomes:

Statistical Techniques provide scientific approaches to develop the domain of human knowledge largely through hempirica lstudies.The course will enable the students to

(a) Understand basi cconcepts and aspects related to research, data collection, analyses and interpretation,
(b) Prepare and finalize research report on some real lifesituations.

Contents:

Unit I **(12 classes)**

Introduction: Meaning, objectives and motivation in research, types of research, research approach, significance of research. Research problems: definition, selection and necessity of research problems.

Unit II **(12 classes)**

Survey methodology and data collection, inference and error in surveys, the target populations, sampling frames and coverage error, methods of data collection, non-response, questions and answers in surveys.

Unit III **(12 classes)**

Processing, Data Analysis and Interpretation: Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation.

Unit IV **(12 classes)**

Develop a questionnaire, collec tsurvey data pertaining to a research problem (such as gender

discriminations in private v/s government sector, unemployment rates, removal of subsidy, impacton service classv/sunorganizedsectors), interpret there sults and draw inferences.

STS102P: Practical/Project based on STS102T

Students should submit a research report based on empirical study on some real life situation.The student will personaly collect, analyze, interpret the data and preparea report under the supervision of a faculty.

References:

1. Kothari,C.R.(2009):ResearchMethodology:MethodsandTechniques,2ndRevised Edition reprint, New Age InternationalPublishers.
2. Kumar,R(2011): Research Methodology:A Step-by-Step Guide for Beginners, SAGE Publications.