Learning Outcomes based Curriculum Framework (LOCF)
for
Statistics
Undergraduate Programme B.Sc. (General)
2019

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

Foreword

UGC has been taking several initiatives for quality improvement in higher education system in the country. Curriculum revision is one of the focus areas of these initiatives. Curriculum development is defined as planned, a purposeful, progressive, and systematic process to create positive improvements in the higher educational system. The ever evolving and fast changing educational technology have posed various challenges as far as curriculum in the Higher Educational Institutions (HEIs) is concerned. The curriculum requires to be updated more often keeping in view the latest developments in the society and to address the society's needs from time to time.

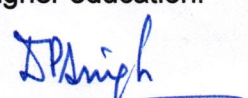
The Quality Mandate notified by UGC was discussed in the Conference of Vice-Chancellors and Directors of HEIs during 26-28th July, 2018; wherein it was inter-alia resolved to revise the curriculum based on Learning Outcome Curriculum Framework (LOCF).

Learning Outcome Curriculum Framework (LOCF) aims to equip students with knowledge, skills, values, attitudes, leadership readiness/qualities and lifelong learning. The fundamental premise of LOCF is to specify what graduates completing a particular programme of study are expected to know, understand and be able to do at the end of their programme of study. Besides this, students will attain various 21st century skills like critical thinking, problem solving, analytic reasoning, cognitive skills, self directed learning etc.. A note on LOCF for undergraduate education is available on the UGC website www.ugc.ac.in. It can serve as guiding documents for all Universities undertaking the task of curriculum revision and adoption of outcome based approach.

To facilitate the process of curriculum based on LOCF approach, UGC had constituted subject specific Expert Committees to develop model curriculum. I feel happy to present the model curriculum to all the HEIs. Universities may revise the curriculum as per their requirement based on this suggestive model within the overall frame work of Choice Based Credit System (CBCS) and LOCF.

I express my gratitude and appreciation for the efforts put in by the Chairperson/Member/Co-opted members/experts of the committees for developing model curriculum. I also take the opportunity to thank Prof. Bhushan Patwardhan, Vice-Chairman, UGC for providing guidance to carry forward this task. My sincere acknowledgement to Prof. Rajnish Jain, Secretary, UGC for all the Administrative support. I also acknowledge the work done by Dr. (Mrs.) Renu Batra, Additional Secretary, UGC for coordinating this important exercise.

All the esteemed Vice-Chancellors are requested to take necessary steps in consultation with the Statutory Authorities of the Universities to revise and implement the curriculum based on the learning outcome based approach to further improve the quality of higher education.



New Delhi
30th July, 2019

(Prof. D. P. Singh)
Chairman
University Grants Commission

Table of Contents

Preamble:

Statistics is used in different ways in different contexts. For a cricket fan, Statistics is the information about runs scored or wickets taken by a player. For the manager of a manufacturing unit, Statistics may be the information about the process control. For a medical researcher investigating the effects of a new drug, Statistics is the evidence of research efforts. For a college student, Statistics shows the grades or marks scored in a course. Thus, in all these illustrations, Statistics refers to quantitative data in the area under study. 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. 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, large amount of data has been handled with the help of computers and more sophisticated statistical techniques can be used in an effective manner to draw valid conclusions. Knowledge of different aspects of Statistics has become crucial in the present scenario. There is a continuous demand for statisticians in fields of education, industry, software and research. The syllabi of three-year B.Sc. (General) degree course in Statistics are framed in such a way that the students at the end of the course, can be thorough in statistical techniques for pursuing higher studies and simultaneously can apply statistical tools judiciously to a variety of data sets to arrive at some valid conclusions.

1. Introduction

B.Sc.(General) Statistics programme consists of 132 credits spread over six 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 in academics.

2. Learning Outcomes Based Approach to Curriculum Planning

2.1 Nature and Extent of the B.Sc. (General) Programme

The B.Sc. (General) 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 opt for outcome based elective courses from the streams such as *Actuarial Statistics, Bio-Statistics, Applied Statistics, Time Series, Clinical Trials and Computational Statistics.*

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.Sc. (General) Statistics programme is of three years duration, with semester 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, correlation and regression techniques.
- During third and fourth semesters**,** students are expected to study statistical inference, designs of experiments and sampling techniques.
- During fifth and sixth semesters, some theory papers and practicals deal with theoretical as well as applied aspects of statistics. Besides, they are supposed to take up a Project Work preferably on a problem related to industries.

2.2 Aims of Bachelor's degree Programme in Statistics

- To prepare graduates who are not only statistically sound but also capable of using their appropriate statistical skills in interdisciplinary areas such as finance, health, agriculture, government, business, industry, telecommunication, and bio-statistics. As a result, they can pursue their future career either in the core field or in the applied field of Statistics.
- To familiarize students with computational techniques and software used in the statistical arena.
- To provide a solid ground in the best practices of collating and disseminating information.
- To prepare students for undertaking further study.
- To teach students to construct practical statistical models for several processes in the real-world.

3. Graduate Attributes in Statistics

- **Disciplinary Knowledge:** The proposed curriculum is expected to provide the students a good overall knowledge of Statistics covering various aspects. As a result, they will not only be able to understand the important statistical techniques but also able to apply some commonly used statistical techniques to other fields.
- **Critical Thinking:** The proposed course is designed to enrich the students with ability to examine basic statistical issues in a more logical and methodical manner. It is expected that the students will strengthen themselves both computationally and analytically.
- **Problem Solving:** The students will be able to examine various hypotheses involved, and will be able to identify and consult relevant resources to find their rational answers.
- **Analytical Reasoning:** The students are expected to develop capability to identify logical flaws and loopholes in the arguments of practicing Statisticians, analyze and synthesize data from a variety of sources and accordingly draw 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 thought provoking 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 a team as well as in isolation.
- **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 behavior such as fabrication, falsification or misrepresentation and misinterpretation of data.
- **Scientific Reasoning:** The students will be able to analyze, interpret and draw appropriate conclusions from both quantitative and qualitative data and critically evaluate ideas, evidence and experiences with an unbiased and consistent approach.
- **Reflective thinking:** The students should be sensitive to real experiences with respect to self, society and nation.
- **Information/Digital literacy:** 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 Statistical computing.
- **Self-directed Learning:** The students are expected to be familiar with data collection, compilation, analysis and interpretation and writing of project reports independently.
- **Multicultural Competence:** 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, building a 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.

4. Qualification Descriptors

Qualification descriptors for a Bachelor's Degree: The qualification descriptors for a Bachelor's degree will

- demonstrate (i) a systematic knowledge of an academic field of study and its applications with a number of emerging issues, (ii) procedural knowledge that creates professionals in the field of Statistics including government and public services, (iii) skills in the areas related to current developments in applications of 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 wide range of ideas and complex problems and issues relating to the chosen field of study.
- communicate the results of studies undertaken in statistics in a range of different contexts using the main concepts, constructs and techniques of the subject.
- address one's learning needs relating to current and emerging areas of study, making use of professional materials as appropriate, including those related to new frontiers of knowledge.
- apply one's statistical knowledge and skills to several contexts and to identify and analyze 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.Sc. (General) Statistics

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

1. Demonstrate the ability to use skills in Statistics and different practicing areas for formulating and tackling Statistics related problems and identifying and applying appropriate principles and methodologies to solve a wide range of problems associated with Statistics.
2. Acquire
   (i) fundamental/systematic or coherent understanding of the academic field of Statistics and its different learning areas and applications.

(ii) procedural knowledge that creates different types of professionals related to subject area of Statistics, including professionals engaged in government/public service and private sectors;

(iii) skills in areas related to one's specialization area within the disciplinary/subject area of Statistics and emerging developments in the field of Statistics.

3. Recognize the importance of statistical modeling and computing, and the role of approximation and mathematical approaches to analyze the real problems using various statistical tools.
4. Plan and execute Statistical experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate statistical software including programming languages, and report accurately the findings of the experiment/investigations.
5. Demonstrate relevant generic skills and global competencies such as
   (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 thinking of Statistics-related issues and problems;
   (iii) communication skills involving the ability to listen carefully, to read texts and reference material analytically and to present 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 with popular language when needed;
   (v) ICT skills;
   (vi) personal skills such as the ability to work both independently and 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 ethical issues in work-related situations;

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

(iv) promoting safe learning and working environment.

5.1. Course Learning Outcomes

Discipline Specific Core (DSC) Papers

ST-DSC-1: Descriptive Statistics

Students will acquire

(a) knowledge of Statistics and its scope and importance in various areas such as Medical, Engineering, Agricultural and 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 organisation and evaluation of summary measures such as measures of central tendency and dispersion etc.

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

(e) insights into preliminary exploration of different types of data.

(f) Knowledge of correlation, regression analysis, regression diagnostics, partial and multiple correlations.

ST-DSC-2: Probability Theory and Distributions

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 and continuous random variables and their probability distributions including expectation and moments,

(d) knowledge of important discrete and continuous distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hyper-geometric, normal, uniform, exponential, beta and gamma distributions,

(e) acumen to apply standard discrete and continuous probability distributions to different situations.

ST-DSC-3: Statistical Inference

The students will acquire

(a) Concept of law large numbers and their uses
(b) Concept of central limit theorem and its uses in statistics
(c) concept of random sample from a distribution, sampling distribution of a statistic, standard error of important estimates such as mean and proportions,
(d) knowledge about important inferential aspects such as point estimation, test of hypotheses and associated concepts,
(e) knowledge about inferences from Binomial, Poisson and Normal distributions as illustrations,
(f) knowledge about order statistics and associated distributions,
(g) concept about non-parametric method and some important non-parametric tests.

ST-DSC-4: Sampling Techniques and Designs of Experiments

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) introduced to various statistical sampling schemes such as simple, stratified and systematic sampling.
(c) an idea of conducting the sample surveys and selecting appropriate sampling techniques,
(d) knowledge about comparing various sampling techniques.
(e) carry out one way and two way Analysis of Variance,
(f) understand the basic terms used in design of experiments,
(g) use appropriate experimental designs to analyze the experimental data,
(h) apply Multiple range tests, the multiple t–test, Student-Newman-Keuls test, Duncan's multiple range test, Tukey's test,

(i) give statistical interpretation of the experimental results obtained.

Discipline Specific Elective (DSE) Courses

ST-DSE-1: Time Series Analysis

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 Average method,
(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) applications to real data by means of laboratory assignments.

ST-DSE-2: Actuarial Statistics

This course is framed to equip the students with concepts of actuarial science and different premium models. After opting for this course, the students will be equipped with knowledge about

(a) modelling of individual and aggregate losses,
(b) fitting of distributions to claims data, deductibles and retention limits, proportional and excess-of-loss reinsurance,
(c) Risk models: models for individual claims and their sums,
(d) finding distribution of aggregate claims, compound distributions and their applications,
(e) applications of credibility theory,
(f) finding of survival function, curate future lifetime, force of mortality,
(g) handling problems on joint life and last survivor status and multiple decrement model,
(h) mean and variance of various continuous and discrete payments for assurance

and annuity contracts,

(i) calculation of various payments from life tables using principle of equivalence, net premiums, prospective and retrospective provisions/reserves,

(j) real illustrations for the concepts mentioned above through laboratory assignments.

ST-DSE-3: Applied Statistics

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

(a) income distributions and their fitting in real life situations,

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

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

(d) Construction and implication of life tables,

(e) Population growth curves, population estimates and projections,

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

ST-DSE-4: Clinical Trials and Epidemiology

The course is of applied nature and will provide the students about

(a) the basic idea of various terminologies in epidemiology, clinical trial experiments involving different phases etc.,

(b) the ethics, principles and conduct of clinical trial experiments with an overall view of Phase I-IV trials,

(c) various data management and data collection systems for a good clinical trial practice,

(d) population pharmacokinetics and pharmacodynamics models applicable in clinical trials,

(e) various clinical trial designs commonly employed in practice,

(f) design and monitoring of Phase III trials with various stopping rule, the inferential aspects including classical methods of interval estimation and hypotheses testing etc.,

(g) design and analysis of epidemiological studies including case-control and cohort study designs,

(h) sufficient practical knowledge by means of laboratory assignments on different types of real life data sets.

ST-DSE-5: Project

Students will opt for a compulsory industrial Project in Semester VI. At the end of this project, students will be in a position to

(a) analyze and interpret and take appropriate decisions in solving real life problems using statistical tools.

(b) use different Statistical packages for graphical interface, data analysis and interpretation,

(c) write a systematic Statistical project report.

Skill Enhancement Courses (SEC)

ST-SEC-1: Computational Techniques and R Programming

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.

ST-SEC-2: Computational Statistics and Database Management System

The students shall be exposed to

(a) various computational algorithms relevant to statisticians as support system,

(b) codes preferably using R language,

(c) Linear congruential and mid-square methods for uniform generator,

(d) Inverse transform method for simulating various probability distributions and stochastic models,

(e) data base management system with special emphasis on significance of topic to the statisticians,

(f) Entity relationship, Relational, Hierarchical and Network Models,

(g) practical assignments on above mentioned topics.

ST-SEC-3: Statistical Techniques for Research Methods

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

(a) understand basic concepts and aspects related to research, data collection, analyses and interpretation,

(b) Prepare and finalize research report on some real life situations.

ST-SEC-4: Programming with C

The students will get acquainted with

(a) various basic concepts, features and components related to C programming language, and structure of C program,

(b) various operators used like logical, assignment, conditional, bitwise in C program,

(c) Control statements, conditional statements, break and continue statements, arrays, etc. in C program,

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

Tables of Course Learning Outcomes

Table 1 B.Sc. Statistics (General)-DSC Courses				
Programme Outcomes	**ST-DSC-1**	**ST-DSC-2**	**ST-DSC-3**	**ST-DSC-4**
Outcome 1	X	X	X	X
Outcome 2	X			X
Outcome 3				
Outcome 4	X	X	X	X
Outcome 5	X	X	X	X
Outcome 6				X

Table 1 B.Sc. Statistics (General)-DSE Courses					
Programme Outcomes	**ST-DSE-1**	**ST-DSE-2**	**ST-DSE-3**	**ST-DSE-4**	**ST-DSE-5**
Outcome 1					X
Outcome 2	X	X	X	X	X
Outcome 3	X		X	X	X
Outcome 4	X	X	X	X	X
Outcome 5	X	X	X	X	X
Outcome 6					X

Table 3 B.Sc. Statistics (General)-SEC Courses				
Programme Outcomes	**ST-SEC-1**	**ST-SEC-2**	**ST-SEC-3**	**ST-SEC-4**
Outcome 1			X	
Outcome 2			X	
Outcome 3	X	X		X
Outcome 4				
Outcome 5	X	X		X
Outcome 6			X	

6. Structure of B.Sc. (Hons) (Statistics)

Course	Credits
I. Core Course (6 credits)	
(4 courses from each of the 3 disciplines of choice)	
(12 Theory papers of 4 credits each)	**12X4=48**
(12 Practicals of 2 credits each)	**12X2=24**
	Total 72 credits
II. Elective Course (6 credits)	
(2 courses from each of the 3 disciplines of choice Including paper of interdisciplinary nature)	
Discipline Specific Elective (DSE)	
(6 Theory papers of 4 credits each)	**6X4=24**
(6 Practicals of 2 credits each)	**6X2=12**
	Total 36 credits
1. Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th semester	
III. Ability Enhancement Courses	
1. Ability Enhancement Compulsory Courses (AECC)	
(2 Theory papers of 4 credits each)	**2X4=08**
2. Skill Enhancement Courses (SEC)	
(4 Theory papers of 3 credits each)	**4X3=12**
(4 Practicals of 1 credit each)	**4X1=04**
	Total 24 credits
Total Credits	**132**

2. University/Institute should evolve a system/policy about ECA/General Interest/Sports/NCC/NSS/related courses on its own.

Sem No.	Discipline Specific Cores (DSC) (12)	Ability Enhancement Compulsory Courses (AECC) (2)	Skill Enhancement Courses (SEC) (4)	Discipline Specific Electives (DSE) (6)
I	1. Descriptive Statistics ---------- 2. 2nd Discipline Core ---------- 3. 3rd Discipline Core	(English/Hindi/ MIL Communication)/ Environmental Science		
II	1. Probability Theory and Distributions ---------- 2. 2nd Discipline Core ---------- 3. 3rd Discipline Core	(English/Hindi/ MIL Communication)/ Environmental Science		
III	1.Statistical Inference ---------- 2. 2nd Discipline Core ---------- 3. 3rd Discipline Core		Computational Techniques and R Programming	
IV	1. Sampling Techniques & Designs of Experiments ---------- 2. 2nd Discipline Core ---------- 3. 3rd Discipline Core		Computational Statistics and Database Management System	
V			Statistical Techniques for Research Methodology	1. Any one from the list of Statistics DSE ---------- 2. 2nd Discipline elective ---------- 3. 3rd Discipline Elective
VI			Programming with C	1. Any one from the list of Statistics DSE ---------- 2. 2nd Discipline elective ---------- 3. 3rd Discipline Elective

Course Code	Course Name	Course Type	Credits (Theory+Practical)
SEMESTER I			
ST-DSC-1	Descriptive Statistics	Statistics Core	6(4+2)
Core	2nd Discipline Core (other than Statistics)	Core	6(4+2)
Core	3rd Discipline Core (other than Statistics)	Core	6(4+2)
AECC-1	(English/Hindi/MIL communication)/ Environmental Science	Ability Enhancement	04
SEMESTER II			
ST-DSC-2	Probability Theory and Distributions	Statistics Core	6(4+2)
Core	2nd Discipline Core (other than Statistics)	Core	6(4+2)
Core	3rd Discipline Core (other than Statistics)	Core	6(4+2)
AECC-2	(English/Hindi/MIL communication)/ Environmental Science	Ability Enhancement	04
SEMESTER III			
ST-DSC-3	Statistical Inference	Statistics Core	6(4+2)
Core	2nd Discipline Core (other than Statistics)	Core	6(4+2)
Core	3rd Discipline Core (other than Statistics)	Core	6(4+2)
ST-SEC-1	Computational Techniques and R Programming	Skill Enhancement	4 (3+1)
SEMESTER IV			
ST-DSC-4	Sampling Techniques & Designs of Experiments	Statistics Core	6(4+2)
Core	2nd Discipline Core (other than Statistics)	Core	6(4+2)
Core	3rd Discipline Core (other than Statistics)	Core	6(4+2)

ST-SEC-2	Computational Statistics and Database Management System	Skill Enhancement	4 (3+1)
SEMESTER V			
Statistics Discipline Elective	Any one from the list of Statistics Discipline Specific Electives	Statistics Discipline Elective	6(4+2)
Elective	2nd Discipline Specific Elective (other than Statistics)	Elective	6(4+2)
Elective	3rd Discipline Specific Elective (other than Statistics)	Elective	6(4+2)
ST-SEC-3	Statistical Techniques for Research Methodology	Skill Enhancement	4 (3+1)
SEMESTER VI			
Statistics Discipline Elective	Any one from the list of Statistics Discipline Specific Electives	Statistics Discipline Elective	6(4+2)
Elective	2nd Discipline Specific Elective (other than Statistics)	Elective	6(4+2)
Elective	3rd Discipline Specific Elective (other than Statistics)	Elective	6(4+2)
ST-SEC-4	Programming with C	Skill Enhancement	4 (3+1)

Discipline Specific Core (DSC) Papers (6 credits each)

ST-DSC-1: Descriptive Statistics

ST-DSC-2: Probability Theory and Distributions

ST-DSC-3: Statistical Inference

ST-DSC-4: Sampling Techniques and Designs of Experiments

Four DSC papers each to be selected from 2nd and 3rd Disciplines

Statistics Discipline Specific Elective (DSE) Papers (6 credits each) (Any 2 papers to be selected out of five)

ST-DSE-1: Time Series Analysis

ST-DSE-2: Actuarial Statistics

ST-DSE-3: Applied Statistics

ST-DSE-4: Clinical Trials and Epidemiology

ST-DSE-5: Project (Sixth semester) (Optional)

Two DSE papers each to be selected from 2nd and 3rd Disciplines Skill Enhancement Courses (SEC) (4 credits each)

ST-SEC-1: Computational Techniques and R Programming

ST-SEC-2: Computational Statistics and Database Management System

ST-SEC-3: Statistical Techniques for Research Methodology

ST-SEC-4: Programming with C

Important Remarks:

1. An internship of minimum 30 days during summer vacations in between 4th and 5th semester is optional to students which will enable them to enhance knowledge of statistics and its actual applications in real life problems.
2. Students are advised to take Mathematics along with Statistics as one of other two disciplines which will give sound foundation for their higher studies.
3. University has complete freedom to suggest their own DSE courses depending upon the availability of teaching staff, their expertise, specialization, requirements, scope and need.

Syllabi of Discipline Specific Core (DSC)

ST-DSC-1: Descriptive Statistics

Credits 6 (Theory: 4 + Practical: 2)

Learning outcomes:

Students will acquire

(a) knowledge of Statistics and its scope and importance in various areas such as Medical, Engineering, Agricultural and 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 organisation and evaluation of summary measures such as measures of central tendency and dispersion etc.

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

(e) insights into preliminary exploration of different types of data.

(f) Knowledge of correlation, regression analysis, regression diagnostics, partial and multiple correlations.

Contents (Theory):

Unit I

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 organizations in India and their functions: CSO, ISI, NSS, IIPS (Devnar, Mumbai), Bureau of Economics and statistics.

Unit II

Population and Sample. Variables: Interval scale, ratio scale, discrete and continuous variables, difference between linear scale and circular scale. Primary and secondary data, Cross-sectional data, time series data, directional data.

Notion of a statistical population: Finite population, infinite population, homogeneous population and heterogeneous population. Notion of a sample and a random sample. Summary Statistics, Review / Revision of Presentation of Data

Unit III

Classification: Raw data and its classification, ungrouped frequency distribution, Sturges' rule, grouped frequency distribution, cumulative frequency distribution, inclusive and exclusive methods of classification, Open end classes, and relative frequency distribution.

Measures of Central Tendency. Partition Values: Quartiles, Deciles and Percentiles (for ungrouped and grouped data), Box Plot, Measures of Dispersion, Moments, Skewness and Kurtosis.

Unit IV

Bivariate data: Scatter diagram, product moment correlation coefficient and its properties, coefficient of determination, correlation ratio, rank correlation, interclass correlation, concept of error in regression, residuals, principle of least squares, fitting of linear regression and related results, regression diagnostics.

Partial and multiple correlation in three variables, their measures and related results.

Theory of attributes: Independence and Association of attributes, various measures of association for two way classified data.

Contents (Practical):

The following is the list of experiments to be done during this course.

1. R programming, importing and exporting data, R functions, loops, conditional statements, R graphics.

2. Diagrammatic representation of statistical data problems based on simple and subdivided bar diagrams, pie diagram.
3. Graphical representation of statistical data.
4. Computation of measures of central tendency and dispersion. Use of an appropriate measure and interpretation of results.
5. Moments, Measures of skewness and kurtosis, Box plot
6. Consistency of data up to 2 attributes. Concepts of independence and association of two attributes.
7. Yule's coefficient of association (Q)
8. Bivariate data: Scatter diagram, plotting and interpretation
9. Calculation of product moment correlation coefficient, correlation ratio, rank correlation
10. Calculation of regression coefficients
11. Fitting of regression lines by least squares
12. Calculation of partial and multiple correlation coefficients for three variables.

References:

1. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I, 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. New Delhi.
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. and Boes, D.C. (2011). Introduction to the Theory of Statistics, 3rd Edn., Tata McGraw-Hill Pub. Co. Ltd.

ST-DSC-2: Probability Theory and Distributions

Credits 6 (Theory: 4 + Practical: 2)

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 and continuous random variables and their probability distributions including expectation and moments,

(d) knowledge of important discrete and continuous distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hyper-geometric, normal, uniform, exponential, beta and gamma distributions,

(e) acumen to apply standard discrete and continuous probability distributions to different situations.

Contents (Theory):

Unit I

Random experiment: Trial, sample point, sample space, definitions of equally likely, mutually exclusive and exhaustive events, definition of probability, classical and relative frequency approach to probability, axiomatic approach to probability and its properties, merits and demerits of these approaches, total and compound probability theorems, conditional probability, independence of events, Bayes theorem and its applications in real life problems.

Unit II

Random Variable: Concept of discrete random variable, probability mass function and distribution function, joint probability mass function of several discrete random variables, marginal and conditional probability mass functions. Expectation of random variables and its properties, conditional expectation, moments in terms of expectation, moment generating function (m.g.f.) and cumulant generating function (c.g.f.), Properties of m.g.f. and c.g.f., Coefficients of skewness and kurtosis based on moments.

Unit III

Continuous Random Variable: Concept of continous random variable, probability density function and distribution function, joint probability density function of several continuous random variables, marginal and conditional probability density functions. Expectation of continuous random variables and its properties, conditional expectation, moments in terms of expectation, moment generating function (m.g.f.) and cumulant generating function (c.g.f.), Properties of m.g.f. and c.g.f., Coefficients of skewness and kurtosis based on moments. Some standard transformed random variables and their distributions.

Unit IV

Some Standard Discrete and Continuous Probability Distributions,
Evaluation of p.m.f., c.d.f., mean, variance, m.g.f. and c.g.f. of the following distributions: Uniform distribution, Bernoulli distribution, Binomial distribution, Poisson distribution, Geometric distribution, Negative binomial distribution, Hypergeometric distribution. Normal distribution and its properties, uniform distribution, exponential distribution, gamma, Weibull and beta distributions.

Contents (Practical):

The following is the list of experiments to be done during this course.

1. Computation of conditional probabilities and probabilities based on Bayes theorem
2. Plotting of discrete distributions and visualization of their shapes for variation in parameters
3. Plotting of continuous distributions and visualization of their shapes for variation in parameters
4. Plots of distribution functions for some important discrete and continuous distributions
5. Fitting of binomial, Poisson, geometric, hypergeometric and negative binomial distributions and computation of expected frequencies, mean variance, m.g.f.
6. Fitting of normal, exponential, gamma, Weibull and beta distributions and computation of expected frequencies, mean variance, m.g.f.
7. Computation of normal probability and interpretation of results.

References:

1. Dudewicz, E.J. and Mishra, S.N. (2008). Modern Mathematics Statistics, Wiley.
2. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
3. Johnson, S. and Kotz, S. (1972). Distribution in Statistics Vol. I-II & III, Houghton and Mifflin.
4. Lipschutz, S., Lipson, M. L. and Jain, K. (2010). Schaum's Outline of Probability. 2nd Edition. McGraw Hill Education Pvt. Ltd, New Delhi.
5. Pitman, J. (1993). Probability. Narosa Publishing House.
6. Rao, C.R. (2009). Linear Statistical Inference and its Applications, 2nd Edition, Wiley Eastern.
7. Rohatgi, V.K. and Saleh, A.E. (2008). An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

ST-DSC-3: Statistical Inference

Credits 6 (Theory: 4 + Practical: 2)

Learning outcomes:

The students will acquire

(a) Concept of law large numbers and their uses

(b) Concept of central limit theorem and its uses in statistics

(c) concept of random sample from a distribution, sampling distribution of a statistic, standard error of important estimates such as mean and proportions,

(d) knowledge about important inferential aspects such as point estimation, test of hypotheses and associated concepts,

(e) knowledge about inferences from Binomial, Poisson and Normal distributions as illustrations,

(f) knowledge about order statistics and associated distributions,

(g) concept about non-parametric method and some important non-parametric tests.

Contents (Theory):

Unit I

Chebyshev's inequality and its applications, basic ideas of convergence in probability and convergence in distribution, law of large numbers, central limit theorem (without proof). Concept of random sample from a distribution, statistic and its sampling distribution, standard error of an estimate, standard errors of sample mean and proportion, sampling distribution of sum of Binomial, Poisson random variables. Sampling distributions of and mean and variance from normal distribution.

Unit II

Formulation of inference problems with concrete illustrations. Point estimation: Different methods and criteria for good estimates. Data analytic illustrations, maximum likelihood estimators and statement of important properties, moment estimators.

Unit III

Tests of hypotheses: Simple, composite null and alternative hypotheses, critical region, types of error, level of significance, p-values, size and power of a test.

Tests for parameters when sampling is done from one and two normal distributions. Tests for parameters of binomial and Poisson distributions. Small sample tests based on chi-square, Students's t and F distributions. Applications of chi-square, Student's t and F distributions

Unit IV

Definition of order statistics and their distributions, sign test, run test, median test, Spearmen's rank correlation test, Sign test, Wilcoxon signed rank test, Wilcoxon Mann-Whitney test, Kolmogorov Smirnov - one sample and two sample tests.

Contents (Practical):

The following is the list of experiments to be done during this course.

1. Testing for parameters when sampling is done from one and two normal distributions.
2. Testing for parameters of binomial and Poisson distributions.
3. Drawing random sample from binomial, Poisson and normal distributions.
4. Point estimates of the parameters of binomial, Poisson and normal distributions.
5. Testing for parameters of binomial, Poisson and normal distributions.
6. Simulation using Box-Muller transformation.
7. Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction.
8. Chi-square test for independence of attributes.
9. Student's t test for single mean and difference of means.
10. The one-sample runs test for randomness – The Sign test – Wilcoxon's Signed Rank Test.
11. Two-Sample Case – Wilcoxon-Mann-Whitney U-test, Kolmogorov – Smirnov two-sample test.

References:

1. Freedman, D., Pisani, R. and Purves, R. (2014). Statistics. 4th Edition. Norton & Comp.
2. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
3. Kendall, M.G. and Stuart, A. (1979). The Advanced Theory of Statistics, Vol. 2. Inference and Relationship. 4th Edition. Charles Griffin & Comp.
4. Kendall, M.G., Stuart, A. and Ord, J.K. (1994). The Advanced Theory of Statistics, Vol. 1. Distribution Theory. 6th Edition. Halsted Press (Wiley Inc.).
5. Kenney, J.F. and Keeping, E.S. (1947). Mathematics of Statistics. Part I. 2nd Edition. Chapman & Hall.
6. Kenney, J.F. and Keeping, E.S. (1951). Mathematics of Statistics. Part II. 2nd Edition. Chapman & Hall.
7. Tanner, M. (1990). An Investigation for a Course in Statistics. McMillan, New York.
8. Tanur, J.M. (1989) Statistics. A Guide to the Unknown. 3rd Edition, Duxbury Press.
9. Yule, G.U. and Kendall, M.G. (1973). An Introduction to the Theory of Statistics. 14th Edition. Charles Griffin & Comp.

ST-DSC-4: Sampling Techniques and Designs of Experiments

Credits 6 (Theory: 4 + Practical: 2)

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) introduced to various statistical sampling schemes such as simple, stratified and systematic sampling.
(c) an idea of conducting the sample surveys and selecting appropriate sampling techniques,
(d) knowledge about comparing various sampling techniques.
(e) carry out one way and two way Analysis of Variance,
(f) understand the basic terms used in design of experiments,
(g) use appropriate experimental designs to analyze the experimental data,
(h) apply Multiple range tests, the multiple t–test, Student-Newman-Keuls test, Duncan's multiple range test, Tukey's test,
(i) give statistical interpretation of the experimental results obtained.

Contents (Theory):

Unit I

Simple Random Sampling (with and without replacement): Notations and terminology, various probabilities of selection. Random numbers tables and its uses. Methods of selecting simple random sample, lottery method, method based on random numbers. Estimates of population total, mean and their variances and standard errors, determination of sample size, simple random sampling of attributes.

Unit II

Stratified random sampling: principles of stratification, notations, estimation of population mean and variances, cost function, allocation techniques, proportional and optimum allocations. Comparison of stratified sampling with simple random sampling.

Unit III

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

Unit IV

Completely randomized design(CRD), Randomized Complete Block Design(RCBD), Latin square design(LSD) and their layout and analyses. Multiple range tests, the multiple t – test, Student-Newman-Keuls test, Duncan's multiple range test, Tukey's test, Fisher's least significant difference test, Scheffe's test, comments on multiple range test.

Contents (Practical):

The following is the list of experiments to be done during this course.

1. Simple Random Sampling – Lottery, random number method and other related problems, Sample size calculation.
2. Systematic Sampling – Problems related to Linear and Circular systematic sampling.
3. Problems related to Systematic sampling with Linear Trend.
4. Stratified Random Sampling – Problems related to Different types of allocation.
5. Stratified Random Sampling – Problems related to Optimum allocation and other related problems.
6. Sample size calculations.
7. One-way analysis of variance, Multiple range tests – The LSD test or the multiple t – test, Student-Newman-Keuls test, Duncan's multiple range test, Tukey's test.
8. Fisher's least significant difference test, Scheffe's test.
9. Completely Randomised Design (CRD), Randomised Complete Block Design (RCBD) – methods, analysis and interpretation.
10. Latin Square Design – methods, analysis and interpretation.

References:

1. Ardilly, P. and Yves T. (2006). Sampling Methods: Exercise and Solutions. Springer.
2. Cochran, W.G. (2007). Sampling Techniques. (Third Edition). John Wiley & Sons, New Delhi.
3. Cochran, W. G. and Cox, G. M. (1957). Experimental Design. John Wiley & Sons, New York.
4. Das, M. N. and Giri, N. S. (1986). Design and Analysis of Experiments (2nd Edition). Wiley.
5. Dean, A. and Voss, D. (1999). Design and Analysis of Experiments. Springer-Verlag, New York.
6. Des Raj. (1976). Sampling Theory. Tata McGraw Hill, New York. (Reprint 1979).
7. Federer, W.T. (1955). Experimental Design: Theory and Applications. Oxford & IBH Publishing Company, Calcutta, Bombay and New Delhi.
8. Joshi, D.D. (1987). Linear Estimation and Design of Experiments. New Age International (P) Ltd. New Delhi.
9. Montgomery, D.C. (2017). Design and analysis of Experiments, 9th Edition. John Wiley & Sons.
10. Mukhopadyay, P. (2007). Survey Sampling. Narosa Publisher, New Delhi.
11. Sampth, S. (2005). Sampling Theory and Methods, 2nd Edition, Alpha Science International Ltd.
12. Singh, D. and Choudhary, F.S. (1977). Theory and Analysis of Sample Survey Designs. Wiley Eastern Ltd, New Delhi. (Reprint 1986)
13. Sukhatme, P.V. and Sukhatme, B.V. (1970). Sampling Theory Surveys with Applications (Second Edition). Iowa State University Press.
14. Thompson, S.K. (2012). Sampling. John Wiley & Sons.

Syllabi of Discipline Specific Electives (DSE) ST-DSE-1:

Time Series Analysis

Credits 6 (Theory: 4 + Practical: 2)

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 Average method,
(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) applications to real data by means of laboratory assignments.

Contents (Theory):

Unit I

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,

Unit II

Fitting of various mathematical curve, and growth curves.

Trend Cont.: Method of moving averages. Detrending. Effect of elimination of trend on other components of the time series.

Unit III

Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend. Seasonal Component count: Ratio to Moving Averages and Link Relative method, Deseasonalization.

Unit IV

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.

Contents (Practical):

1. Fitting and plotting of modified exponential curve.
2. Fitting and plotting of Gompertz curve.
3. Fitting and plotting of logistic curve.
4. Fitting of trend by Moving Average method.
5. Measurement of Seasonal Indices Ratio-to-Trend method.
6. Measurement of Seasonal Indices Ratio-to-Moving Average method.
7. Measurement of seasonal indices Link Relative method.
8. Calculation of variance of random component by variate difference method.
9. Forecasting by exponential smoothing.
10. Forecasting by short term forecasting methods.

References:

1. Box, G.E.P., Jenkins, G.M., Reinsel, G.C. and Ljung, G.M. (2015). Time Series Analysis: Forecasting and Control. 5th Edition. John Wiley & 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, John Wiley.
7. Mukhopadhyay, P. (2011). Applied Statistics, 2nd ed. Revised reprint, Books and Allied Pvt. Ltd.

ST-DSE-2: Actuarial Statistics

Credits 6 (Theory: 4 + Practical: 2)

Learning Outcomes:

This course is framed to equip the students with concepts of actuarial science and different premium models. After opting for this course, the students will be equipped with knowledge about

(a) modelling of individual and aggregate losses.
(b) fitting of distributions to claims data, deductibles and retention limits, proportional and excess-of-loss reinsurance.
(c) Risk models: models for individual claims and their sums.
(d) finding distribution of aggregate claims, compound distributions and their applications,
(e) applications of credibility theory.
(f) finding of survival function, curate future lifetime, force of mortality.
(g) handling problems on joint life and last survivor status and multiple decrement model.
(h) mean and variance of various continuous and discrete payments for assurance and annuity contracts.
(i) calculation of various payments from life tables using principle of equivalence, net premiums, prospective and retrospective provisions/reserves,
(j) real illustrations for the concepts mentioned above through laboratory assignments.

Contents (Theory):

Unit I

Probability Models and Life Tables, Loss distributions: modelling of individual and aggregate losses, moments, fitting distributions to claims data, deductibles and retention limits, proportional and excess-of-loss reinsurance. Risk models: models for individual claims and their sums,

Distribution of aggregate claims, Compound distributions and applications, Introduction to credibility theory.

Unit II

Survival function, curate future lifetime, force of mortality. Multiple life functions, joint life and last survivor status. Multiple decrement model. Life Contingencies: Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor.

Unit III

Assurance and annuity contracts: definitions of benefits and premiums, various types of assurances and annuities, present value, formulae for mean and variance of various continuous and discrete payments.

Unit IV

Calculation of various payments from life tables: principle of equivalence, net premiums, prospective and retrospective provisions/reserves.

Contents (Practical):

(a) modelling of individual and aggregate losses.

(b) moments, fitting distributions to claims data, deductibles and retention limits, proportional and excess-of-loss reinsurance. Risk models: models for individual claims and their sums.

(c) finding distribution of aggregate claims, compound distributions and their applications,

(d) applications of credibility theory.

(e) finding survival function, curate future lifetime, force of mortality.

(f) problems on joint life and last survivor status and multiple decrement model.

(g) finding mean and variance of various continuous and discrete payments for assurance and annuity contracts.

(h) Calculation of various payments from life tables using principle of equivalence, net premiums, prospective and retrospective provisions/reserves.

References:

1. Boland, P. (2007). Statistical and Probabilistic Methods in Actuarial Science. Chapman and Hall/CRC.
2. Borowaik, D.S. and Shapiro, A. F. (2013). Financial and Actuarial Statistics: An Introduction. 2nd Edition. Marcel Dekker Inc., New York-Basel.
3. Bowers, N. L., Gerber H. U., Hickman, J. C., Jones, D. A. and Nesbitt, C. J. (1997). Actuarial Mathematics, 2nd Edition, Society of Actuaries, USA.
4. Deshmukh, S.R. (2005). Actuarial Statistics: In Introduction Using R. Narosa Publishing House, New Delhi.
5. Klugman, S. A., Panjer, H. H. and Willmot, G. E. (2013). Loss Models: Further Topics, 4thEdition. Wiley-Interscience.
6. Promislow, S. D. (2014). Fundamentals of Actuarial Mathematics. 3rd Edition. Wiley.

ST-DSE-3: Applied Statistics

Credits 6 (Theory: 4 + Practical: 2)

Learning Outcomes:

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

(a) income distributions and their fitting in real life situations,

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

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

(d) Construction and implication of life tables,

(e) Population growth curves, population estimates and projections,

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

Contents (Theory):

Unit I

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, Engel curve analysis using cross-section and time series data, Engel curves incorporating household characteristics, demand projection, specific concentration curves.

Unit II

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

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

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.

Contents (Practical):

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 dataset, for entire range as well as specific range.
3. Fitting of a Lorentz curve for a data and computation of the concentration ratio using graphical method.
4. Calculation of Crude birth rate; General fertility rate; Age specific fertility rate; Total fertility rate; Gross reproduction rate; Net reproduction rate.
5. Calculation of Infant mortality rate, Crude death rate, Age specific death rates.
6. Computation of standardized birth and death rates.
7. Construction of life tables.
8. Population growth curves, population estimates and projections.

References:

1. Benjamin, B. (1959). Health and Vital Statistics. Allen and Unuwin.
2. Cramer, J.S. (1969). Empirical Econometrics. North Holland 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). A Text Book of Demography. Vikas Publishing House.
10. Shryock, H.S. (1971). The Methods and Materials in Demography. U.S. Bureau of Census.

ST-DSE-4: Clinical Trials and Epidemiology

Credits 6 (Theory: 4 + Practical: 2)

Learning Outcomes:

The course is of applied nature and will provide the students about

(a) the basic idea of various terminologies in epidemiology, clinical trial experiments involving different phases etc.,

(b) the ethics, principles and conduct of clinical trial experiments with an overall view of Phase I-IV trials,

(c) various data management and data collection systems for a good clinical trial practice,

(d) population pharmacokinetics and pharmacodynamics models applicable in clinical trials,

(e) various clinical trial designs commonly employed in practice,

(f) design and monitoring of Phase III trials with various stopping rule, the inferential aspects including classical methods of interval estimation and hypotheses testing etc.,

(g) design and analysis of epidemiological studies including case-control and cohort study designs,

(h) sufficient practical knowledge by means of laboratory assignments on different types of real life data sets.

Contents (Theory):

Unit I

Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I – IV trials, multicenter trials.

Data management: data definitions, case report forms, database design, data collection systems for good clinical practice. Bioavailability, bioequivalence, area under curve, rate of absorption of drug, rate of elimination, maximum concentration of drug and time of maximum concentration of drug. Pharmacokinetics and pharmacodynamics.

Unit II

Design of clinical trials: parallel group versus cross-over designs; cross-sectional versus longitudinal designs, wash-out period, control arms, single arms, active control, placebo; observational trials: prospective, retrospective; case-control, matching, cohort studies, quantitative methods in screening.

Unit III

Design and monitoring of phase III trials with sequential stopping, design of bioequivalence trials. Inference for 2X2 cross over design, classical methods of interval hypothesis testing for bioequivalence. Introduction to Meta-analysis of clinical trials.

Introduction to modern epidemiology, principles of epidemiologic investigation, surveillance and disease monitoring in populations.

Unit IV

Epidemiologic measures: organizing and presenting epidemiologic data, measure disease frequency, measures of effect association, causation and causal inference.

Design and analysis of epidemiologic studies: types of studies, case-control studies, cohort studies, quantitative methods in screening.

Contents (Practical):

1. Data preparation, cleaning and obtaining summary measures from clinical data.
2. Computation of odds ratio, Attributable Risk, risk ratio and relative risk.

3. Computation of bioavailability, bioequivalence, area under curve, rate of absorption of drug, rate of elimination, maximum concentration of drug and time of maximum concentration of drug.
4. Calculation of test of significance of cross-over effects, treatments effects and sequence of treatment effects.
5. Systematic representation of epidemiological data using statistical package.
6. Computation of disease frequency.
7. Calculation of effect association of disease using various measures.
8. Calculation of causation and causal inference for given epidemiological data.

References:

1. Chow, S.C. and Liu, J.P. (2004). Design and Analysis of Clinical Trials. 2nd Edition. Marcel Dekker.
2. Chow, S.C. and Liu, J.P. (2009). Design and Analysis of Bioavailability and Bioequivalence. 3rd Edition. CRC Press.
3. Fleiss, J.L. (1989). The Design and Analysis of Clinical Experiments. Wiley and Sons.
4. Friedman, L.M., Furburg, C. and Demets, D.L. (1998). Fundamentals of Clinical Trials. Springer.
5. Jekel, J.F., Elmore, J.G. and Katz, D.L. (1996). Epidemiology, Biostatistics and Preventive Medicine. WB Saunders Co.
6. Jennison, C. and Turnbull, B.W. (1999). Group Sequential Methods with Applications to Clinical Trials. CRC Press.
7. Marubeni, E. and Valsecchi, M.G. (1994). Analyzing Survival Data from Clinical Trials and Observational Studies. Wiley and Sons.
8. McNeil, D. (1996). Epidemiological Research Methods, Wiley and Sons.
9. Piantadosi, S. (1997). Clinical Trials: A Methodologic Perspective. Wiley and Sons.
10. Rothman, K.J. and Geenland, S. (1988). Modern Epidemiology. Lippincott-Raven.
11. Selvin, S. (1996). Statistical Analysis of Epidemiologic Data. Oxford University Press.

ST-DSE-5: Project

Students will opt for a optional industrial Project in Semester VI. A copy of rules and regulations regarding completion and submission of the project work by a student and assessment of the project work to make available in the Department of Statistics in each university. Students should use advanced statistical tools in their project and submit the dissertation at the end of the semester. There will be subsequent presentations and seminars by the students along with project supervisor, internal subject expert and Head of the Department. The grades on the presentation and evaluation of the project will be given by the subject expert and project supervisor allotted to the student. The project has to be completed within a semester. At the end of this project, students can analyze and interpret and take appropriate decisions in solving real life problems using statistical tools in the present situations.

Learning Outcomes:

At the end of this project, students will be in a position to

(a) analyze and interpret and take appropriate decisions in solving real life problems using statistical tools.

(b) use different Statistical packages for data analysis and interpretation,

(c) write a systematic Statistical project report.

Syllabi of Skill Enhancement Courses (SEC)

ST-SEC-1: Computational Techniques and R Programming

Credits 4 (Theory: 3 + Practical: 1)

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 (Theory):

Unit I

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

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

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

Unit III

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

Unit IV

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.

Contents (Practical):

Practicals are based on the topics of the theory mentioned above.

References:

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

5. Peter N. (1986). Inside the IBM PC, Prentice-Hall Press.

ST-SEC-2: Computational Statistics and Database Management System

Credits 4 (Theory: 3 + Practical: 1)

Learning Outcomes:

The students shall be exposed to

(a) various computational algorithms relevant to statisticians as support system,

(b) codes preferably using R language,

(c) Linear congruential and mid-square methods for uniform generator,

(d) Inverse transform method for simulating various probability distributions and stochastic models,

(e) data base management system with special emphasis on significance of topic to the statisticians,

(f) Entity relationship, Relational, Hierarchical and Network Models,

(g) practical assignments on above mentioned topics.

Contents (Theory):

Unit I

Graphical methods with applications: histogram, Quantile based plot (boxplot and Q-Q plot), scatter diagram, time series plot, autocorrelation plot.

Computation of the normal integral, Student's t-integral, non-central t integral, Gamma, Beta integral for positive real numbers. Computation of incomplete beta and incomplete gamma integral, computation of Bessel function and modified Bessel function.

Unit II

Generation of uniform random numbers (mid-square method and linear congruential generator).

Simulation of probability distributions and stochastic models (Inverse transformation method only). Applications of simulation techniques.

Unit III

Introduction. Purpose of database systems. Database abstraction. Data models. Instances and schemes. Data independence. Data definition and data manipulation languages. Database manager, Administrators and users.

Unit IV

Entity relationship model, Entities and entity sets. Relationships and relationship sets, Attributes, Mapping constraints, Keys, Entity relationship diagram. Reducing E-R diagrams to tables. Aggregation, Design of an E-R database scheme.

Relational models. Structure of relational database. Distributed database. Relational algebra. Relational commercial languages. SQL. Relational database design. Query languages and query processing. Crash recovery. Concurrency control. Hierarchical model. Network model.

Contents (Practical):

Practicals are based on the topics of the theory mentioned above.

References:

1. Date, C.J. (1981). Introduction to Database Systems, Addison-Wesley.
2. Kennedy W. J. & Gentle J. E. (1980). Statistical Computing, Marcel Dekker.
3. Korth, H.F. and Silberschatz, A. (2010). Database System Concepts, McGraw-Hill.
4. Ross, S.M. (2012). Simulation. Academic Press.
5. William H. P. and William T. V. (1992). Numerical Recipes in C: The Art of Scientific Computing, Cambridge University Press.

ST-SEC-3: Statistical Techniques for Research Methods

Credits 4 (Theory: 3 + Practical: 1)

Learning Outcomes:

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

(a) understand basic concepts and aspects related to research, data collection, analyses and interpretation,

(b) Prepare and finalize research report on some real life situations.

Contents (Theory):

Unit I

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

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

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

Develop a questionnaire, collect survey data pertaining to a research problem (such as gender discriminations in private v/s government sector, unemployment rates, removal of subsidy, impact on service class v/s unorganized sectors), interpret the results and draw inferences.

Contents (Practical):

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 a report under the supervision of a faculty.

References:

1. Kothari, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Edition reprint, New Age International Publishers.

2. Kumar, R (2011): Research Methodology: A Step - by - Step Guide for Beginners, SAGE Publications.

ST-SEC-4: Programming with C

Credits 4 (Theory: 3 + Practical: 1)

Learning Outcomes:

The students will get acquainted with

(a) various basic concepts, features and components related to C programming language, and structure of C program,

(b) various operators used like logical, assignment, conditional, bitwise in C program,

(c) Control statements, conditional statements, break and continue statements, arrays, etc. in C program,

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

Contents (Theory):

Unit I

History and features of C language, components of C language, structure of a C program. Data type: Basic data types, enumerated data types, derived data types. Variable declaration, local, global, parametric variables, assignment of variables, numeric, character, real and string constants, arithmetic relation and logical operators, assignment operators, increment and decrement operators, conditional operators, Bitwise operators, type modifiers and expressions, writing and interpreting expressions, using expressions in statements. basic input / output.

Unit II

Control Constructs I: Control statements, conditional statements, if . . . . . else, nesting of if . . . . . else, else lf ladder, switch statements. Loops in C: for, while, do . . . . . while loops. Control Constructs II: Break, continue, exit ( ), go to and label declarations. One dimensional two dimensional and multidimensional arrays.

Unit III

Storage classes: Automatic variables, External variables, Static variables, Scope and lifetime of declarations. Functions, classification of functions, functions definition and declaration, assessing a function, return statement, parameter passing in functions, revise on in Functions.

Unit IV

Structure: Definition and declaration; structure (initialization) comparison of structure variable array of structures: array within structures, structures within structures, passing structures to functions, unions accessing a union member, union of structure, initialization of a union variable, uses of union.

Contents (Practical):

Practicals are based on the topics of the theory mentioned above.

References:

1. Balagurusamy, E. (2004). Programming in ANSI C. 3rd Edition. Tata McGraw Hill.
2. Gottfried B. S. (1996). Theory and problems of Programming with C. 2nd edition. Tata McGraw Hill.
3. Kanetkar, Y.P. (2003). Working with C. BPB Publication.
4. Schildt, H. (1985). C Made Easy. McGraw Hill.
5. Schildt, H. (2010). C The Complete Reference, 3rd Edition. Tata McGraw Hill.

7. Teaching Learning Processes

The teaching learning processes play the most important role in achieving the desired aims and objectives of the undergraduate programs in Statistics as elaborated in detail in the Learning Based Curriculum Framework (LOCF). Statistics is the science which deals with data collection, analysis and interpretation of numerical data. While such ideas and concepts originate in the minds of the genius, anywhere and anytime in the universe, their verifications and confirmations have to be done in the data analysis. To achieve this goal, the appropriate training of young individuals to become competent statisticians in future have to be accomplished. For this purpose, a very good undergraduate program in Statistics is the first step. We should therefore have an excellent teaching-learning procedural protocol for all the colleges, universities and other Higher Education Institutions (HEI). To be specific, it is desirable to have:

- Necessary and sufficient infrastructural facilities for the class rooms, laboratories and libraries equipped with adequate modern and modular furnitures and other requirements.
- Modern and updated computer laboratory equipments are needed for the undergraduate programme.
- Recent reference and text books for the libraries are to be updated.
- Sufficient infrastructure for ICT and other facilities needed for technology-enabled learning like computer facilities, PCs, laptops, Wi-Fi and internet facilities with all the necessary software.
- Sufficient number of teachers in permanent position to do all the class room teaching and perform and supervise the computer laboratory experiments to be done by the students.
- All the teachers should be qualified as per the UGC norms and should have good communication skills.
- Sufficient number of technical and other support staff to run the laboratories, libraries, equipment and maintain the infrastructural facilities like buildings, electricity, sanitation, cleanliness etc.
- Teachers should make use of all the approaches for an efficient teaching-learning process i.e.

(i) Class room teachings with lectures using traditional as well as electronic boards,

(ii) Use of smart class rooms for conveying the difficult concepts and tools of Statistics in class room teaching and laboratories,

(iii) Tutorials must be an integral part of all the theory and laboratory courses. Theory courses should have 1-2 tutorials every week depending upon the nature of the course,

(iv) Teaching should be complimented with student's seminar to be organized very frequently,

(v) Guest lectures and seminars/workshops should be arranged by eminent teachers to be invited by the concerned college/university/HEI,

(vi) Open-ended project work should be given to all students individually or in group to 2-3 students depending upon the nature of the course,

(vii) Internship of duration varying from one week anytime in the semester and/or 2-6 weeks during semester break and summer breaks should be arranged by the college/universities/HEI for the students to visit other colleges/universities/HEI and industrial organizations in the

vicinity. If needed, financial assistance may also be provided for such arrangements to be made for their internship in industries.

(viii) Special attempts should be made by the institution to develop problem-solving skills and design of Statistics projects for demonstration at the UG level. For this purpose, a mentor system may be evolved where 3-4 students may be assigned to each faculty member.

(ix) Teaching load should be managed such that the teacher has enough time to interact with the students to encourage an interactive/participative learning.

8. Assessment Methods

In the undergraduate education of Statistics leading to the B. Sc. (General) Statistics degree, the assessment and evaluation methods focus on testing the conceptual understanding of the basic ideas, development of mathematical skills and experimental techniques retention and ability to apply the knowledge acquired to explain with analysis and reason what has been learnt and to solve new problems and communicate the results and findings effectively. Since the learning objectives are defined clearly for each course in detail, it is easier to design methods to monitor the progress in achieving the learning objectives during the course and test the level of achievement at the end of the course.

- The courses offered in the undergraduate Statistics are the first courses at the college/university level, the priority should be given to Formative Assessment for monitoring the progress towards achieving the Learning Objectives while keeping its weightages lower than Summative Assessments. This is to assure that the students know their strengths and weaknesses periodically through the results of Formative Assessments and make amends for the gaps in their knowledge without affecting their final grades in any significant way. In this context it is suggested that 25-30% weightage be given Formative Assessments in case of theory components while 30-40% weightage be given to the Laboratory/Field work/Projects/Case Study/Dissertation components of the various courses. Moreover, use of more than one method of Assessment in each course is highly recommended.
- Some of the methods suggested for Theory Component with regard to Formative Assessment are i) Regular Tutorial assignments ii) seminar presentations iii) Performance

in group discussions iv) Problem based longer assignments (other than tutorials) v) True/False Tests vi) Multiple Choice Tests vii) Short Answer Tests viii) viva-voce tests ix) Any other innovative tests in the context of the course.

- In the case of substantive Summative Assessment for the theory papers, can be a combination of the following i) Mid -Semester test ii) Seminar Report iii) Individual /Team Project report iv) Oral Presentations of Seminar/Projects v) Viva -Voce Examination on the above reports.
- End Semester closed book examination in the pattern of a) Multiple Choice b) Short Answer c) Long Answer.
- End Semester Open Book Examination in the form of a) Peer review by written and oral examination, b) Any other innovative method depending upon the nature of the course.
- B. Laboratory Experiments / Field work / Projects / Case Study / Dissertation can be assessed for Formative Assessment through i) Regular evaluation of Lab. experiments regarding written report of each experiment and Viva-Voce on each experiment ii) Mid semester examination.
- At the end, the main purpose of Statistics teaching should be to impart objective knowledge to students in concrete, comprehensive and effective way. Here, effectiveness implies gaining knowledge and skill which can be applied to solve practical problems as well as attaining capability of logical thinking and imagination which are conducive to new knowledge and new discoveries. The student shall embrace the curriculum in a way which would incite imagination and imbibe a spirit of enquiry in them, so that in future they will opt for further investigations or research. Needless to say, there should be a continuous evaluation system for the students. This will enable the teachers not only to ascertain the overall progress of learning by the students, but also to identify the students who are slow learner and for whom special care should be taken. An appropriate grading system is the

  'relative grading system' can also be envisaged for certain papers, introducing a competitive element among the students. All in all, the teacher should act as a facilitator and guide and not as a guardian of curriculum.
- HEIs can design their own ways and methods to quantify the assessment and evaluation based on the above methods. It would then be converted to the letter grades by the procedure described by the template given by the UGC.

- Once the letter grade for a course is obtained for a course, it should be done for all the courses offered by the student. Once the letter grades for all the courses are accumulated, then a CGPA should be calculated by quantifying the letter grades as described by the template provided by the UGC.

9. Key Words

- Actuarial Statistics
- Analytical reasoning
- Clinical trials
- Communication skills
- Course Learning outcomes
- Critical thinking
- Design of Experiments
- Disciplinary knowledge
- Graduate outcomes
- Nonparametric inference
- Probability theory
- Probability distributions
- Problem solving
- Program learning outcomes
- Qualification descriptors
- Regression analysis
- Research-related skills
- Sampling Techniques
- Scientific reasoning
- Skill development
- Statistical inference
- Testing of hypotheses and
- Time series analysis.

Expert Committee Members of Learning Outcomes based Curriculum Framework (LOCF) Statistics

Prof. David D. Hanagal, CAS Department of Statistics, University of Pune, Pune – 411 007.

Prof. Satyanshu Kumar Upadhyay, Department of Statistics, Banaras Hindu University, Varanasi-221005

Prof. Kanchan K. Jain, DSA Department of Statistics, Panjab University, Chandigarh – 160 014.

Prof. A. Rajarathinam, DRS Department of Statistics, Manonmaniam Sundaranar University, Tirunelveli