SEMESTER SYSTEM OF P. G. STATISTICS

P. G. SEMESTER EXAMINATION REGULATIONS

CHAPTER - I

REGULATION OF GENERAL ACADEMIC MATTERS

The Departments shall follow Semester System of teaching and Examination based on continuous evaluation internally as well as externally subject to moderation of question papers. The system of evaluations of the students shall be based on Course Credit System.

Academic Year

The Academic Year of the department shall ordinarily be from JUNE to MAY. It may however be modified by the Staff Council from time to time.

Semester

The academic year shall have two semesters, each of which shall be of 6 months duration.

Minimum working days in a Semester

A Semester shall have a minimum of 90 working/instructional days excluding examination days/Sundays/Holidays etc. The minimum number of classes in a semester shall not fall short of the number of classes as mentioned below.

1. One Credit hour courses = 10 classes minimum
2. Two Credit hour courses = 20 classes minimum
3. Three Credit hour courses = 30 classes minimum
4. Four Credit hour courses = 40 classes minimum

Credit hours

One credit shall signify the quantum of teaching imparted corresponding to one hour of theory class and two hours of laboratory/project work and two hours of seminar per week during a semester in respect of a particular course. Each teachinghouroftheoryclasswillbeof60minutes and practical classes/project work will be of 120 minutes duration and seminar will be of 120 minutes duration. For field study outside headquarters, one working day will be considered as two teaching hours. However, the field study should not exceed 30 days (including Sundays) in one semester.

The P. G. Syllabus may be so designed that the total of credit hours for all four semesters shall be 88 spread equally over all semesters as far as practicable, tutorials and proctorials shall be treated as non-credit components.

Course

A course is a Unit of instruction under any discipline carrying a specific number of credit hours describing its weightage. Those courses, which a student must take as compulsory requirement, are, called Core Courses. Those courses, which a student opts out of a list of specialized courses offered by the department, are called Elective Courses.

Grade

Thegradeawardedtoastudentinanyparticularcourseshallbebasedonhis/herperformanceinall the tests conducted during a semester and shall be awarded at the end of the semester. The grade in each course is expressed in numerical value in 10.00 scale. The marks of a student shall be converted to10.00 scale and the points scored thereby shall be called the "Grade Point" in the course. Respective "Grade Point Average" (GPA) and "Overall Grade Point Average" (OGPA) shall be awarded at the end of each semester and all semester respectively.

A 3.0 Grade Point isrequired for passing in individual paper and 4.0 GPA to pass any semester examination. The G.P. shall be rounded to one decimal point and GPA to two decimal points.

Grade Point Average (G.P.A.)

Grade Point Average (G.P.A.) of a semester shall be calculated as:

$$GPA = \frac{\text{Summation of } \{(\text{Credits in each course}) \times (\text{Grade point in that course})\}}{\text{Total No. of Credits in that Semester}}$$

Where the summation is taken over all courses in a given semester, G.P.A. shall be rounded up to 2 decimal points.

O.G.P.A. (Overall Grade Point Average)

It is the average of accumulated grade points of a student, worked out by dividing the cumulative total of grade points by the cumulative total of credit hours of all the courses covered and completed by a student during all the Semesters. For the first semester of the programme the GPA and OGPA shall be the same.

$OGPA = \frac{\sum A \times B}{C}$, where A=Credits in each semester, B=Total Credits in that semester &C= Total No. of Credits in that Semester

The summation is taken over all semesters in a given programme. OGPA shall be rounded up to e decimal points. For merit lists, in case of equality, the OGPA shall be calculated beyond two decimal places if necessary.

Conversion of grades to marks and classification of results under course credit systemThe OGPA can be converted to percentage of marks in the following manner: Percentage of Marks = (OGPA) ×10

A student after successful completion of all the semesters, Degree shall be awarded inthe following manner:

O.G.P.A.	6.0	: FIRST CLASS
O.G.P.A.	5.0 -<6.0	: SECONDCLASS
O.G.P.A.	4.0 - <5.0	: THIRDCLASS
O.G.P.A.	<4.0	:FAIL

Academic Calendar

The Examination Section and the academic section shall finalize the schedule of

semester registration and other academic activities at the start of academic session. TheAcademic Calendar shall be prepared by the Academic Committee of the University in consultation with examination section.
The broad format for academic calendar for P. G. with regard to admission, registration and commencement of classes shall be as follows:

Admission and Registration and Commencement of Classes for1stSemester	JULY
1stSemesterExamination	DECEMBER
Commencement of Classes for 2ndSemester	JANUARY-MAY
2ndSemesterExamination	JUNE
Commencement of 3rdSemesterClasses	JULY-NOVEMBER
3rdSemesterExamination	DECEMBER
Commencement of 4thSemesterClasses	JANUARY-APRIL
4thSemesterExamination	APRIL & MAY
Final Results to be published in the month of	JUNE

Requirement of award of degree

The minimum credit hour requirement for the Master Degree shall be 88 (Eighty Eight) credits and the residence required for Master Degree shall be continuous four semesters from the first date of registration and the maximum time allowed to complete the Master Degree shall be 8 (eight) semesters.

Requirement for attendance

A candidate shall be required to attend 75% lectures, tutorials and practical classes separately during the semester (For late admitted students' attendance to be calculated from the date of admission). Condonation may be granted by the staff council only to the extent of 15% in exceptional cases. (Illness, accident, mishap in the family, deputation by University/Department). When a candidate has been deputed by the University to represent the University/state for any activity, the lectures delivered during his/her absence for the purpose shall not be counted towards the calculation of attendance provided the student submits a certificate to that effect from the appropriate authority.

Registration in a semester

A student has to register his/her name at the beginning of every semester in the prescribed form, for the course he/she wants to take in that semester. Examination Section (General) shall notify the registration dates and the list of registered students for the semester shall be given to the Head of the Department within two weeks of the commencement of the Semester.

CHAPTER - II

REGULATIONS ON EXAMINATION MATTERS

Mid Term Examination

In each Semester there shall be one Mid Term Assessment examination of 60 minutes duration. The Mid Term examination shall be conducted by COE like that of End Term examination. The answer scripts shall be evaluated by the external and internal examiners and the marks along with answer scripts shall be

retained in COE.

Semester Examination

After the end of each semester there shall be an examination of each theory paper of 2 hours duration and of each practical paper of 4 hours duration, which shall be called Term End / "Semester Examination". The maximum marks for each theory paper shall be 50 out of which 40 marksfortermendand10marksforMidTerm. The classes shall remain suspended 10 (ten) days (including Sundays and holidays, if any) before the date of commencement of semester test for preparation by the students.

Results of Examinations

The results shall be declared ordinarily within four weeks of completion of the examinations. A student who seeks re-addition of his/her marks in a course shall be allowed to do so by submitting an application to Registrar along with a required fees in the fee counter of the University. All such cases/complaints if any shall be disposed of by the Examination Section in a prefixed day and necessary corrections if any shall be reflected in the mark/grade sheet. The candidates shall have to appear in all the Units of a semester examination to be eligible to be a declared 'pass' provided he/she secures minimum pass marks/grade.

Promotion to the next semester

A student shall be admitted to the next semester only when he/she appears in all the papers of the concerned semester examination. However, a student failing to appear semester examination in some or of all papers due to some reasons as mentioned in 2.5 may be admitted to the next semester. Such a student shall produce sufficient proof in favour of his/her reason for not being able to appear in some or all papers of the Semester Examination on the next academic session in the corresponding semesters.

Absence from Examination

If a student is unable to appear a semester examination in some or all papers the Registrar shall consider his/her case for admission into the next higher semester only the following cases:

(a) When he/she is hospitalized.
(b) When he/she is not be able to appear in the examination due to serious illness or deathof parents, brothers, sisters, spouse or children.
(c) When he/she met an accident of serious nature.
(d) When the department/University or any official directive deputes him/her

Procedure for Repeat/Improvement

A student who wants to sit for the semester examination of first and/or second semester in the subsequent academic session (for repeat or improvement) he/she shall have to apply to the Registrar in plain paper before fifteen days of the commencement of the said examination. If allowed by the Registrar, he/she shall deposit the required fees for each paper with center charge and produce the proof to the teacher in-charge examination with permission letter from the Registrar.

In a semester to appear improvement examination the candidates must have passed thesemester examination. A candidate can appear repeat examination of papers in which he/she has failed or not appeared for reasons mentioned in 2.5.

The Master Degree student seeking to appear/improvement examination in any course(s)shall get 3 chances for 1st and 2nd semester within 8 semesters.
Candidates appearing in repeat/improvement examination shall not be considered in the merit list and it shall be reflected in the Provisional Certificate cum Mark sheet (PCM) but not in the final degree certificate.

Award of Degree Certificate, Grade/Marksheet

A Degree certificate under the official seal of the university and signed by the Vice - Chancellor shall be presented at the Convocation or in absentia to each of the successful students of particular degree. The Controller of Examinations shall issue the mark/grade sheet of each semester to the candidates in the sheet of each semester to the candidates in the prescribed format by depositing the required fees for marks/Grade Sheet to be deposited in the University counter.

Guideline for filling up of Forms for PG Classes (IMP/Repeat)
A student shall repeat all the theory and practical papers in which he/she failed in the semester examination within a period of eight semesters from the date of first registration. Such students shall have to apply to the Head of the Department/Registrar in plain paper during the filling up of form for the ensuing semester examination. If allowed, he/she shall deposit the fees as prescribed by the University.
If a candidate secures less than 3.0 Grade point in a paper(s) and less than 4.0 Grade point average in a Semester examination he/she has to appear all the papers in that Semester.

If a candidate secures less than 3.0 Grade Point in a paper(s) and a minimum 4.0 Grade point average in a semester examination, he/she has to appear only the paper(s)in which he/she secured less than 3.0 Grade point.

A candidate is eligible to sit for improvement in a paper(s) only when he/she has passed the semester examination concerned. Further, he/she can improve in a maximum of EIGHT paper(s)in the entire course. The Master Degree students seeking to take improvement examination in any course(s) shall get chances within 8 semesters from the year of admission to the course. The candidates taking this advantage (improvement) will be examined on the basis of current syllabus and the higher marks shall be retained during computation of result.

If a candidate fails to appear in any paper of the said examination and marked ABSENT his/her results will be declared only when he/she clears that paper/those papers.

Disciplines in the Examination

(A) Late Comers: A student arriving in the examination hall/room fifteen minutes after the commencement of the examination shall not be ordinarily allowed to sit for the examination. No examinee shall be allowed to go out of the examination hall within one hour of commencement of examination. The invigilators shall keep a record of temporary absence of students from the examination hall/room during the examination.

(B) Adoption of unfair means in the Examination:
Possession of unauthorized materials and using it, copying from scripts of other students or from any other source, showing his/her answer script to others during the examination, creating disturbance or acting in a manner so as to cause in convenience to other students in the examination hall or near about shall be treated as adoption of unfair means or mal practice.

SEMESTER SYSTEM OF P. G. STATISTICS

Paper Code	Paper Title	Marks	Credits Hours
	SEMESTER- I		
ST-101	Mathematical Analysis and Linear Algebra	20+80	4
ST-102	Statistical Methods	20+80	4
ST-103	Probability Theory –I	20+80	4
ST-104	Statistical Inference-I	20+80	4
ST-105	Statistical Computing-I using SPSS	100	4
	Total	**500**	**20**
	SEMESTER- II		
ST-201	Probability Theory –II	20+80	4
ST-202	Statistical Inference-II	20+80	4
ST-203	Survey Sampling Methods	20+80	4
ST-204	Operations Research	20+80	4
ST-205	Statistical Computing–II: C Programming	100	4
ST-206	Elective (DSE): Demography & Vital Statistics	20+80	4
	Total	**600**	**24**
	SEMESTER- III		
ST-301	Multivariate Analysis	20+80	4
ST-302	Design and Analysis of Experiments	20+80	4
ST-303	Stochastic Processes	20+80	4
ST-304	Non-Parametric Methods	20+80	
ST-305	Statistical Computing-III: R Programming	100	4
ST-306	Elective (IDSE): Statistical Methodology	20+80	4
	Total	**600**	**24**
	SEMESTER- IV		
ST-401	Linear Model and Regression Analysis	20+80	4
ST-402	Any **one** paper out of the following papers: 1. *Econometrics* 2. Advanced Survey Sampling Methods 3. Advanced Design and Analysis of Experiments 4. Advanced Operations Research	20+80	4
ST-403	Any **one** paper out of the following papers: 1. *Time Series Analysis and Statistical Quality Control* 2. Reliability Theory	20+80	4
ST-404	Any one paper out of the following papers: 1. *Official Statistics* 2. Actuarial Statistics 3. Quantitative Epidemiology 4. Survival Analysis& Clinical Trials 5. Big Data Analytic Techniques	20+80	4
ST-405	Project Work and Seminar Presentation	100	4
	Total	**500**	**10**
	Grand Total	**2200**	**88**

Note (Red: Employability, Green: Entrepreneurship, Blue: Skill Development)

NB: *Departmental Specific Elective: Open Elective (DSE)Operations Research (ST - 206),Inter Disciplinary Specific Elective: Open Elective (IDSE) Biostatistics (ST-306), Mid-term 20 & End term 80*

PROGRAMME OBJECTIVES

The objectives of 2 years (4 Semester) M.A/M.Sc. Statistics Programme is:

1. To inculcate and develop aptitude to apply statistical tools at a number of data generating fields in real life problems.
2. To train students to handle large data sets and carry out data analysis using software and programming language.
3. To teach wide range of statistical skills, including problem-solving, project work and presentation so as to enable students to take prominent roles in a wide spectrum of employment and research.

DETAILED SYLLABUS

SEMESTER - I

ST-101: MATHEMATICAL ANALYSIS AND LINEAR ALGEBRA 4 CREDITS

Course Objectives: The learning objectives include:

1. Introduction to the fundamental concept of real analysis such as sequence, series of real numbers and their convergence, continuity, differentiability of real valued functions.
2. Enhancement to learn the basic ideas of abstract algebra and techniques with proof in pure mathematics and further, it can be used in many other courses.

Course Outcomes (CO): After completing this course, students will be able to develop a clear understanding of

1. Fundamental properties of the real numbers that lead to the formal development of real analysis.
2. Comprehension of rigorous argument developing the theory under pinning realanalysis.
3. Limits and how they are used in sequences, series, differentiation and integration. Construct rigorous mathematical proofs of basic results in real analysis.
4. Abstract ideas and rigorous methods in mathematical analysis to solvepractical problems.
5. The concept of metric space.
6. Using the basic concepts of vector and matrix algebra, including linear dependence / independence, basis and dimension of a subspace, rank and nullity, for analysis of matrices and systems of linear equations.
7. The characteristic polynomial to compute the eigen values and eigenvectors of a square matrix and use them to diagonalizable matrices when this is possible.

UNIT-I

Sequence and series, convergence, Bolzano-Weirstrass theorem, Heine Borel theorem. Real valued function, continuous functions, Uniform continuity, sequences and series of functions, Uniform convergence. Differentiation, maxima-minima of functions.

UNIT-II

Functions of several variables, partial and total differentials, maxima-minima of functions, multiple integrals, change of variables in multiple integration, Improper Integrals, Convergence of improper integrals of first and second kinds.

UNIT-III

Metric space - limits and metric space, continuous functions in metric spaces, connectedness, completeness and compactness. Normed linear Spaces. Spaces of continuous functions as examples.

UNIT-IV

Vector spaces, linear dependence and independence, Dimension and basis, orthonormal basis, Matrix: Characteristic roots and vectors, Cayley-Hamilton theorem, minimal polynomial, similar matrices, spectral decomposition of a real symmetric matrix, Hermitian matrix. Real quadratic forms, reduction and classification of quadratic forms.

Books Recommended

1. Ruddin, Walter: Principles of Mathematical Analysis, McGraw-Hill.
2. Goldberg, R.R.: Methods of Real Analysis, Oxford & IBH Publication
3. Apostal, T.M.: Mathematical Analysis, Narosa Publishing House
4. Graybill, F.E.: Matrices with Applications in Statistics, 2nd ed., Wadsworth
5. Searle, S.R.: Matrix Algebra Useful for Statistics, John Wiley & Sons
6. Strang, G. (1980). Linear Algebra and its Application, 2nd edition, Academic Press, London-New York

ST-102: STATISTICAL METHODS 4 CREDITS

Course Objectives: The learning objectives include:

1. Introduction to Statistics.
2. Understanding the nature of data with the help of various statistical tools.
3. Understanding the concept of Probability and probability distributions.

Course Outcomes (CO): After completing this course, students will have clear understanding of-

1. The fundamental concepts of statistics
2. Measures of location and dispersion

3. Bivariate data, Significance of various coefficients of correlation
4. Fitting of linear and nonlinear curve
5. Introduction of variables and their pmf, pdf and cdf
6. Discrete and Continuous Probability distributions and its applications
7. Order statistics and their distributions and properties

UNIT-I

Descriptive Statistics: Measures of central tendency, dispersion, skewness and kurtosis for the study of nature of data. Idea of correlation and regression for two and three variables; correlation coefficient, correlation ratio, multiple and partial correlations.

UNIT-II

Some discrete statistical distributions: Binomial, Poisson, hypergeometric, negative binomial and multinomial distributions. Some continuous distributions (Normal, Uniform, Exponential, Cauchy, Pareto, Weibull, lognormal), Bivariate normal and bivariate exponential family of distributions and their properties.

UNIT-III

Functions of random variables and their distributions using Jacobian and other tools, convolution and compound distributions, truncated and mixture distributions, Sampling distributions from normal population, Chi-square, t and F distributions and Non-central chi-square, t and F distributions.

UNIT-IV

Order statistics and their distributions and properties. Joint and marginal distributions of order statistics. Extreme values and their asymptotic distribution (statement only) with applications, Asymptotic distribution of median, distribution of quantiles.

Books Recommended

1. Hogg, R.V. and Craig, A.L. (1978). Introduction to Mathematical Statistics, MacMillan, New York.
2. Mood, A.M., Graybiil, F.A. and Boes, D.C. (2001). Introduction to Theory of Statistics, Tata McGraw Hill, New Delhi.
3. Ross, Sheldon M (2004) Introduction to Probability and Statistics for Engineers and Scientist, Third Edition, Elsevier Academic Press, USA.
4. Rohatgi V.K. and Saleh, A.K. Md. E. (2001). An Introduction to Probability and Statistics (Second Edition), John Wiley and Sons (Asia), Singapore.
5. Dudew icz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics, John Wiley, New York.
6. Johnson, S and Kotz, S. (1970). Continuous univariate Distributions Iand II John Wiley, New York.
7. David, W.S. (2003): Order Statistics (Second Edition). John Wiley andSons, New York.

ST-103: PROBABILITY THEORY-I **4 CREDITS**

Course Objectives: The learning objectives include:

1. The introduction of set, series, sequence, limit, field, probability measures &Properties.

2. The concept of random variables (RV), functions of RVs, Joint pdf, pmf and cdf, conditional and marginal, use of Jacobian of transformation, moments, expectations, mgf, chf, and some inequalities.

3. Understanding of convergence, strong law and weak law of large numbers

Course Outcomes (CO): After completing this course, students will be able to develop a clear understanding of:

1. The fundamental concepts of probability and their applications in day todaylife
2. Application of inequalities.
3. Limiting approach and different laws, Markov and Chebychev's inequality
4. Statement and applications of WLLN and SLLN.
5. Central limit theorem (CLT) for i.i.d. variates, and its applications

UNIT-I

General Probability space, Various definitions of probability, probability axioms, properties of probability, conditional probability, Bayes' theorem and its applications.

UNIT-II

Concept of random variables, cumulative distribution function and probability density function, joint, marginal and conditional distribution. Brief review of joint, marginal and conditional probability density function, functions of random variables and their distributions using Jacobian of transformation.

UNIT-III

Mathematical expectation, moments, conditional expectation, moment generating functions, cumulative generating functions and their applications, Characteristic function, uniqueness theorem, Levy's continuity theorem (statement only). Probability inequalities and their applications: Chebyshev, Markov and-Jenson.

UNIT-IV

Convergence in probability and convergence in distribution, weak law of large numbers, Sequence of events and random variables: Zero one law of

Borel and Kolmogorov, almost sure convergence in mean squares, Khintchin's weak law of large numbers, Kolmogorov inequality, and strong law of large numbers.

Books Recommended

1. P.G. Hoel, S.C. Port and C.J. Stone, Introduction to

probability Universal Book Stall, New Delhi,1998.
2. Sheldon Ross, A first course in Probability, 8th Edition, Prentice Hall, 2009.
3. Loeve (1996): Probability Theory Affiliated East–West Press Pvt. Ltd. New Delhi.
4. Bhatt, B.R. (2000): Probability, New Age International India.
5. Feller, W. (1971): Introduction to Probability Theory and its applications, Vol. I and II. Wiley, Eastern-Ltd.
6. Rohatgi, V.K(1984): An Introduction to Probability Theory andMathematical Statistics, Wiley Eastern.
7. Billingsley, P. (1986): Probability and Measure, John Wiley Publications.

ST-104: STATISTICAL INFERENCE-I 4 Credits

Course Objectives: The learning objectives include:

1. Concept of point and interval estimation.
2. Concept of properties of estimators and their estimation.
3. Concept of large sample properties of estimators
4. Analysis and interpretation of the unbiasedness and MVUE and relatedtheorems.

Course Outcomes (CO): After completing this course, students will be able to develop the skills concerning:

1. Parameter, statistic, standard error, sampling distribution of a statistic etc.
2. Characteristics of a good estimator, different methods of estimation.
3. Use of inferential techniques in data analysis.

UNIT I

Point Estimation, Properties of estimators, Unbiasedness, Consistency, Sufficiency, Neyman Factorization Criterion, Minimal sufficient statistic, Invariance properties of sufficiency, Completeness.

UNIT II

Mean Square Error, Unbiasedness and minimum variance, Minimum Variance Unbiased estimator (MVUE), C-R inequality, Cramer Rao lower bound, Rao- Blackwell Theorem, Chapman-Robbins Inequality, Lehmann-Scheffe Theorem, Necessary and sufficient conditions for MVUE.

UNIT III

Consistent estimators, Sufficient condition for consistency, Efficient estimators, Methods of estimation: Method of Maximum Likelihood (MLE) and its properties, Method of Moments, Method of Least squares, Method of Minimum Chi-Square and Modified Minimum Chi-Square, Method of Percentiles. Consistent Asymptotic Normal (CAN) estimators, Properties of CAN estimators.

UNIT - IV

Interval estimation – confidence level, construction of confidence intervals, shortest confidence intervals, uniformly most accurate one -sided confidence intervals, unbiased confidence intervals, confidence coefficient.

Books Recommended:

1. E.L. Lehmann (1998): Theory of Point Estimation, John Wiley and Sons.
2. Rohatgi V.K. and Saleh, A.K. Md. E. (2001). An Introduction to Probability and Statistics (Second Edition), John Wiley and Sons (Asia), Singapore.
3. B.K. Kale (1999) A First Course in Parametric Inference, Naros a Publishing Company.
4. Robert C.P. and Casella, G (1999) Monte-Carlo Statistical Methods,Springer Verlag.
5. Mukhopadhay, P (1999) Mathematical Statistics, New Central BookAgency Pvt. Ltd.
6. Hogg, R.V. and Craig, A.T. (1971): Introduction to MathematicalStatistics, Princeton University Press.

ST- 105: STATISTICAL COMPUTING-I USING SPSS 4 CREDITS

Course Objectives: To understand the basic concepts of SPSS:

1. Define a variety of statistical variables
2. Enter basic data into SPSS
3. Carry out a statistical analysis that can test hypotheses of small and large samples and fitting of distributions.

Course Outcomes (CO):

1. After completing the course students can able to construct frequency distribution and calculate different statistical measures like measures of central tendency, measures of dispersion skew and kurtosis, can present data in graphical form and interpret the data.
2. Student can Correlation and regression analysis and perform testing of hypothesis for small sample and large sample tests.
3. Students can fit Binomial, Poisson, Normal distribution and test the goodness of fit.

Data analysis using SPSS.

I. Frequency distribution, measures of central tendency, dispersion, moments, skewness and kurtosis
II. Correlation, regression, rank correlation
III. Test of hypothesis - *t* and *F* tests, chi-square test, *z* test
IV. Fitting of distributions.

Books Recommended

1. Rajaraman,V, "Fundamentals of Computers", PHI
2. Norton , Peter (2001), "Introduction to Computers", 4th Ed., TMH.
3. Berk, K.N. & Carey, P. (2000): Data Analysis with Microsoft Excel, DuxburyPress

Marks Distribution

PART-A: Computer application and Data Processing - 20 marks

PART- B: Data analysis using Excel and SPSS - 60 marks

VIVA-VOCE + RECORDS - 20 MARKS

SEMESTER - II

ST- 201: PROBABILITY THEORY- II 4 CREDITS

Course Objectives: The learning objectives of this paper deal with:

1. Introduction of non-central probability distributions.
2. Concept of convergence on a probability space in distributions and some inequalities.
3. Understanding the concept of characteristic function and their related theorems.
4. Concept of convergence, strong law and weak law of large numbers.

Course Learning Outcomes: After completing this course, students will have clear understanding of-

1. The fundamental concepts of non-central chi-square, t and F distributions and their applications.
2. An idea about convergence in probability and distributions along with their relationship, characteristic functions and applications on the basis of inequalities.
3. Limiting approach and different laws.

UNIT-I

Field, sigma field, minimal sigma field, Borel sigma field, set functions. Measure and its properties, measurable functions and inverse functions.

UNIT-II

Product sigma-fields, Borel sigma-field on Euclidean spaces. Extensions of measures, Caratheodory's theorem (statement). Lebesgue measure on R and Rk: construction, properties. Convergence on a probability space – convergence in distribution (law), convergence in probability, convergence in *r*-th mean, convergence almost surely and their relationships.

UNIT-III

Integration: simple, nonnegative, general measurable functions, integrability, Monotone Convergence Theorem, Dominated Convergence Theorem, Fatou's lemma. Change of variables. Lp spaces, Holder's and Minkowski's inequalities.

UNIT-IV

Laws of large numbers –Bernoulli's laws of large numbers. Hajek-Reni inequalities. Central limit theorem – Lindberg –Levy and Liapounov forms with proofs and applications. Lindberg-Feller form (without proof).

Books Recommended:

1. Rohatgi, V.K. and Ehsanes Saleh, A.K.M.: An Introduction to Probabilityand Statistics, 2nd ed., Wiley-Inter Science
2. Bhat, B.R.: Modern Probability Theory, 3rd Edition, New Age International.
3. Gun, A.M., Gupta, M.K. and Das Gupta, B.: An Outline of Statistical Theory, Vol-I (4thed.), World Press
4. Ash, R.B. and Doleans-Dade, C.A.: Probability and Measure Theory. Elsevier.
5. Billingsley, P: Probability and Measure. John Wiley.
6. Sen, A. K: Measure and Probability. Narosa Publishing House.
7. Feller, W: An Introduction to Probability Theory and its Applications, VolJohn Wiley.

ST- 202: STATISTICAL INFERENCE-II 4 CREDITS

Course Objectives: The learning objectives include:

1. Understanding of hypothesis testing and its applications. Concept of Likelihood ratio tests and its development of critical region and testing of hypothesis.
2. Concept of SPRT, OC and ASN functions and their usefulness for differentprobability distributions.

3. Techniques of non-parametric inferences and their uses in data analysis

Course Outcomes (CO): After completing this course, students will be able to develop the skills concerning:

1. The construction and development of MP tests, UMP tests under simple and composite hypothesis.
2. Construction of similar regions and unbiased tests. They will also acquire the skill of testing hypothesis relating to parameters of normal distribution using LR methods
3. Perform hypothesis testing and selection of sample applying the rules of SPRT
4. Differentiate between parametric and non-parametric tests, non-parametric alternatives of the parametric tests.
5. Analyse the data using non-parametric methods and valid statistical inference.

UNIT-I

Tests of hypothesis, concepts of critical regions, two kinds of errors, power function, MP and UMP test, Neyman-Pearson Lemma, MP test for simple null against simple alternative hypothesis. UMP tests for simple null hypothesis against composite alternative.

UNIT-II

Type A and type A1 tests, similar tests, tests having Neyman structure, The Likelihood Ratio Test (LRT), One-tailed and two-tailed likelihood ratio tests for mean and variance of normal populations, Asymptotic property of LRT and

applications, Monotone Likelihood Ratio Test and applications

UNIT-III

Wald's sequential probability ratio test and its properties, OC and ASN function, derivation of OC and ASN functions, Efficiency of SPRT, SPRT for a Composite Hypothesis.

UNIT-IV

Non-parametric inference: Goodness of fit tests- Chi square test and Kolmogorov Smirnov test for one and two sample problems, Sign test, Signed rank test, Wald-Wolfowitz run test, Median test, Man-Whitney U-test, Non-parametric confidence intervals, Bootstrapping confidence intervals, P-P Plot and Q-Q plot, Tests for independence and homogeneity.

Books Recommended

1. Kale, B.K.: A First Course on Parametric Inference, Narosa PublishingHouse
2. Rohatgi, V.K. and Ehsanes Saleh, A.K.M.: An Introduction to Probabilityand Statistics, 2nd ed., Wiley-Inter science.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory,Vol. II, (4thed.), World Press.
4. Lehmann E. L& Romano, J.P. (2005): Testing Statistical Hypotheses.Springer.
5. Gibbons, J.D.&Chakraborti, S. (2003): Nonparametric Inference, McGraw- Hill.

ST- 203: SURVEY SAMPLING METHODS 4 CREDITS

Course Objectives: The learning objectives include:

1. This course introduces participants to what survey sampling is, why it isimportant, and how it is implemented.
2. Types of samples (probability versus non-probability) and estimation techniques

Course Learning Outcomes: After completing this course, students will have clear understanding of-

1. Participants will achieve an awareness of the critical issues in introductory survey sampling which can then be used to assess existing surveys or aid in creating new ones.
2. How to construct a 'sampling frame' Types of probability samples (e.g., simple random, systematic, stratified, multi-stage clustered, unequal probabilities of selection)
3. Concept on methods of estimation in sampling e.g., ratio, product, difference and regression.

4. What 'sampling error' is, the role of sampling error in confidence intervals.
5. How to determine sample size and the effects of different types of sample designs on confidence intervals

UNIT-I

Basic concepts of finite population and sampling techniques, Errors in surveys. Simple random sampling with and without replacement. Determination of sample size. Probability proportional to size sampling with replacement, the Hansen-Hurwitz and the Horvitz-Thompson estimators.

UNIT-II

Stratified random sampling – estimation of population mean/total with standard error and its estimate, problems of allocations, comparison with unrestricted sampling.

Systematic sampling – method of selection, estimation of population mean/total, sampling variance, comparison with simple random sampling and stratified sampling, efficiency for structural populations.

UNIT-III

Cluster sampling – equal size, estimation of population mean/total, standard error and its estimation, comparison with mean per unit estimator.

Two-stage sampling with equal first stage units, estimation of population mean/total, standard error and its estimation, comparison with single-stage sampling, Three-stage sampling.

UNIT-IV

Use of auxiliary information in sample surveys, Methods of estimation – ratio, product, difference and regression methods, sampling variance and efficiency of the estimators, Double sampling.

Books Recommended:

1. Cochran, W.G.: Sampling Techniques, 3rd ed., Wiley
2. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C.: Sampling Theory of Surveys With Applications, Indian Soc. of Agric. Stat., New Delhi
3. Swain, A.K.P.C.: Finite Population Sampling – Theory & Methods, South Asian Publishers
4. Sampath, S: Sampling Theory and Methods. Narosa Publising House.
5. Mukhopadhyay, Parimal: Theory and Methods of Survey Sampling. PrenticeHall.
6. Murthy, M. N: Sampling Theory and Methods. Statistical Publishing Society.

ST-204: OPERATIONS RESEARCH 4 CREDITS

Course Objectives: The learning objectives of this paper deal with:

1. Definition & scope of operations research in management of Scarce resources.
2. Importance of inventory management, determination of economic order quantity(EOQ) and models formulation
3. Concept of game and determination of optimal strategies.

Course Learning Outcomes: After completing this course, students will have clear understanding of:

1. Formulation of LPP and its optimum solution through simplex method, developing economic interpretation of duality
2. Formulation of the transport problem and optimize their cost by different methods.
3. Formulation of nonlinear programming problems and its optimum solutionthrough Kuhn-Tucker, Wolfe's and Beale's algorithms.
4. Formulation, optimum solutions of general inventory models with shortages, models with probabilistic and random demands.
5. Network scheduling through CPM and PERT.
6. Solution of two-person zero sum game by simplex method, Simulation techniques and application of uncertainty through Fuzzy sets.

UNIT-I

Definition and Scope of Operations Research: Phases in Operation Research, models. Solving LPP by Simplex method and solutions to LPP by applying duality theorem, economic interpretation of duality, Karmakar interior point algorithm.

UNIT - II

Transportation, Assignment and Transshipment problems, Travelling salesman's problem, Non-linear programming – constrained optimization and Kuhn-Tucker conditions, Wolfe's and Beale's algorithm.

UNIT-III

Analytical structure of inventory problems, Harris EOQ formula, its sensitivity analysis, extension allowing quantity discounts and shortages, multi-item inventory models, probabilistic inventory problems, Models with random demand, the static risk model. P and Q-systems with constant and random lead times. Network scheduling by PERT/CPM.

UNIT-IV

Game theory: Two-person Zero sum game, Maximin-Minimax principle, Games without saddle points, $2 \times n, n \times 2$ and $m \times n$ games, Dominance property, Simulation model, Monte-Carlo simulation, Introduction to fuzzy sets, fuzzy measures, fuzzy relations, fuzzy set theory and applications.

Books Recommended:

1. Taha, H.A. (1992): Operational Research: An Introduction, Mc. Millan.

2. Kanti Swarup, Gupta, P.K. and Man Mohan (2007): Operations Research,Sultan Chand & Sons.
3. Ravindran, A., Phillips, D.T. and Solberg, J.J. (2009): Operations Research:Principles and Practice, Wiley-India.
4. Zimermann, H.J. (2001): Fuzzy Set Theory and its Applications, 2nd ed.,Allied Publishers.
5. Lee, K.H. (2006): Fuzzy logic and Its Applications, Springer.

ST- 205: STATISTICAL COMPUTING-II: C PROGRAMMING 4 CREDITS

Course Objectives: The learning objectives of this paper deal with-

1. To understand computer programming and its roles in problem solving.
2. To develop programming skills using the fundamentals and basics of C language.
3. To enable effective usage of arrays, functions and pointers.

Course Outcomes (CO): After completing this course, students will have clear understanding of-

1. The fundamental concepts of C programming language.
2. Various data types, operators, library functions, Input/Output operations.
3. Decision making and branching and looping.
4. Arrays.
5. User defined functions, recursion functions.
6. Storage class of Variables.

UNIT-I

Introduction: Introduction to C programming, Keywords and Identifiers, Constants, variables, Input and Output Operations, Compilation and Pre-Processing, **Data types:** Different data types, Data types qualifier, modifiers, Memory representation, size and range, **Operators**: Operators (Arithmetic, relational, logical, assignment, increment/decrement, Bitwise, Assignment &Compound assignment, Conditional). Operator types (unary, binary, ternary). Expressions, Order of expression (Precedence and associativity), Decision making and branching - if...else, nesting of if...else, else if ladder, switch, conditional operator.

UNIT-II

Looping in C: for, nested for, while, do...while, jumps in and out of loops. **Arrays:** Declaration and initialization of one-dim and two-dim arrays. Character arrays, **Pointers:** Concept of Pointer (null pointer, wild pointer, dangling pointer, generic pointer), Pointer expressions, Accessing the address of a Variable, Declaring Pointer Variables, Initializations of Pointer

Variable, Accessing a Variable through its pointer, Pointer arithmetic. **Strings:** Declaring and initializing string variables, reading and writing strings from Terminal (using scanf and printf only).

UNIT-III

Storage class: Types (auto, register, static, extern), scope rules, declaration and definition. **Function:** Function & types (User- defined functions, library function), Function Definition, Declaration, Function Calls, Header file and library, Function Arguments, String handling function (strlen, strcmp, strcpy, strncpy, strcat, strstr), Function recursion, Functions Returning Pointers, Pointers to Functions, Command line arguments, Application of Pointer (dynamic memory allocation).

UNIT-IV

Structure and Union: Defining, Declaring, Accessing, Initialization Structure, nested structure, self-referential structure, bit-field, Arrays of Structure, Structures and Functions, Unions, difference between structure and union, active data member, structure within union.

File: File Management in C, Defining and Operating a File, File opening modes (read, write, append), Closing a File operations, file and stream, Error Handling During I/O Operations, Sequential and random access file, low level and high level file.

Books Recommended:

1. E. Balaguruswamy, "Programming in ANSI C", 4/e, (TMH)
2. B. Kerninghan & Dennis Ritchie, "The C Programming Language", 2/e PHI
3. Paul Deitel, Havery Deitel, " C: How to Program", 8/e, Prentice Hall.

Marks Distribution:

Programming	- 80 marks
Viva-voce + Records	- 20 marks

ST- 206: (DSE) DEMOGRAPHY& VITAL STATISTICS 4 CREDITS

Course Objectives:

The learning objectives include:

1. To collect valid Demographic data using different methods.
2. To learn basic measures of Mortality, Fertility and Population Growth.
3. To construct life tables.

Course Outcomes (CO): After completing this course, students will have clear understanding of

1. Distinction between Vital Statistics and Demography.
2. Errors in Demographic data.
3. To check the completeness of registration data using Chandrasekaran-Demingformula.

4. Use of Myer's and UN indices in evaluating age data.
5. Use of Balancing Equations.
6. Population Composition and Dependency Ratio.
7. Sources of data collection on Vital Statistics and errors therein.
8. Measurement of Population.
9. Distinction between Rate and Ratio.
10. Basic measures of Mortality.
11. Concepts of Stable and Stationary Populations.
12. Concept of Life Tables, their construction and uses.
13. Basic measures of Fertility.
14. Measures of Population Growth.
15. Migration Models

UNIT-I

Coverage and errors in demographic data, Chandrasekharan Deming formula. Adjustment of age data, Whiples, Mayers and UN indices. Population projection methods: Component & Growth Models, Leslie Matrix, Population distribution: Lorenz curve and Gini concentration ratio, Population pyramid.

UNIT-II

Measures of fertility (period and cohort), Coales fertility index, Measures of reproduction, Calculation of PPR, Model age patterns of fertility: Brass Polynomial model & Coale-Trussell model. Nuptiality rate, Net Nuptiality table, Proportion Single and Singulate. Mean age at marriage, Hajnal's method of estimating SMAM, Mean duration of fertile union.

UNIT-III

Measures of mortality, comparative mortality index, Lexis Diagram and IMR, life table functions, Construction of Reed Merell, Greville life table, UN and Coale-Demeny model life tables, multiple decrement life table, Age decomposition of differences in life expectancies at birth, Model age patterns of mortality, Fitting Grompertz law, Estimation of Child mortality (Brass method)

UNIT-IV

Measures of internal migration & international migration methods of estimation, Migration models. Models of population growth: A simple Birth and Death process, Immigration process, Emigration process, Birth-Emigration process, Immigration-Emigration process. Stationary and stable population models, Simplified example of stable population, Lotka's demonstration of conditions producing a stable population . The equations characterizing a stable Population, Identification of the intrinsic growth rate, Construction of a stable equivalent population, Momentum of population growth and its estimation.

Books Recommended

1. Pathak, K.B. and Ram, F.: Techniques of Demography Analysis, HimalayanPublishers

2. Srinivasan, K.: Basic Demographic Techniques and Applications, SagePublishers
3. Ramkumar, R.: Technical Demography, Wiley Eastern.
4. S.H. Preston, P.Heuveline& M. Guillot, Blackwell, 2003_-Demography
5. Applied Mathematical Demography by Nathan Keyfitz, Springer Verl

ST-301: MULTIVARIATE ANALYSIS 4 CREDITS

Course Objectives: The learning objectives include:

1. To learn and develop scientific view to deal with multidimensional data sets and its uses in the analysis of research data.
2. To understand the extensions of univariate techniques to multivariate frameworks and learn to apply dimension reduction techniques used in thedata analysis.

Course Outcomes (CO): After completing this course, students will have clear understanding of

1. Understand multivariate normal distribution and their real life applications.
2. Understand Wishart distribution, Hotelling T^2 and Mahalanobis D^2 statistic.
3. Implement dimension reduction techniques using software on real lifeproblems.
4. Demonstrate knowledge and understanding of the basic ideas behind discriminant and clustering analysis, factor analysis and principal componentanalysis techniques with applications.

UNIT-I

Multivariate normal distribution – distribution of linear combination of normally distributed variables, marginal and conditional distributions, distribution of quadratic forms. Maximum likelihood estimators of parameters, distributions of sample mean vector and matrix of corrected sum of squares and cross products.

UNIT-II

Estimation of partial and multiple correlation coefficients and their sampling distributions (null case only). Hotelling's T^2 statistic – properties, distribution and uses, tests on mean vector for one and more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population. Mahalanobis – D^2 statistic and its use.

UNIT-III

Classification and discrimination procedures – discrimination between two multivariate normal populations, sample discriminant function, tests

associated with discriminant functions, probabilities of misclassification and their estimation, classification into more than two multivariate normal populations. Fisher's discriminant function.

UNIT-IV

Cluster Analysis, Factor Analysis, Wishart matrix – distribution and properties, characteristic function, reproductive property, marginal and conditional distributions. Distribution of sample generalized variance. Principal components: definition, MLE of principal components and their variances. Canonical variables and canonical correlations – definition, use, estimation and computation.

Books Recommended:

1. Anderson, T.W.: An Introduction to Multivariate Statistical Analysis, 2nd ed., Wiley
2. Morrison, D.F.: Multivariate Statistical Methods, 2nd ed., McGraw-Hill
3. Giri, N.C: Multivariate Statistical Inference. Academic Press, NY
4. Rao, C.R: Linear Statistical Inference and Its Application. John Wiley.
5. Sharma, S: Applied Multivariate Techniques, John Wiley.

ST-302: DESIGN & ANALYSIS OF EXPERIMENTS 4 CREDITS

Course Objectives: The learning objectives include:

1. To learn the basic principles of design of experiments like randomization, replication, general design models various designs and multiple comparison tests are studied.

Course Outcomes (CO): After completing this course, students will have clear understanding of

1. After completing this course, students will acquire the knowledge of field experiments in agriculture, medicine, marketing, finance and insurance fields.

UNIT-I

Analysis of variance – components and models, analysis of variance of one-way and two-way fixed and random effect models, variance component estimation and study of various methods, tests for variance components. Analysis of unbalanced data. Principles of designs of experiment, experimental error and data interpretation.

UNIT-II

Complete block designs - completely randomized designs, randomized block designs, latin square designs, Graeco-Latin square designs, cross-over designs. Missing plot techniques – general theory and applications.

UNIT-III

Analysis of covariance. General factorial experiments, factorial effects, best

estimates and testing the significance of factorial effects, study of 2^n, 3^2, 3^3 factorial experiments in randomized blocks. Confounding in 2^n, 3^2 and 3^3 factorial experiments - complete and partial confounding, advantages and disadvantages, construction and analysis, fractional replication for symmetric factorials.

UNIT-IV

Incomplete block designs – balanced incomplete block design, parametric equality and inequality, intra-block analysis, analysis with recovery of inter-block information. Split plot and strip plot designs – models and analysis.

Books Recommended:

1. Das, M.N. and Giri, N.C.: Designs of Experiments, New Age International.
2. Kempthorne, O.: Design and Analysis of Experiments, Wiley Eastern.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Vol.II, (4^{th} ed.), World Press.Dey, Aloke: Theory of Block Designs. New Age International.
4. Dean, Angela and Voss, Daniel: Design and Analysis of Experiments. NewAge International.
5. Chakrabarty, M.C.: Mathematics of Design of Experiments. Asian pub.House.
6. Montgomery, C.D.: Design and Analysis of Experiments. John Wiley, NewYork.

ST-303: STOCHASTIC PROCESSES 4 CREDITS

Course Objectives: The learning objectives include:

1. To learn and to understand stochastic processes predictive approach.
2. To develop an ability to analyze and apply some basic stochastic process for solving real life situations.

Course Outcomes (CO): After completing this course, students will have clear understanding of

1. Understand the stochastic processes, Markov chains, Transition probability matrix and various types of states.
2. Explain Random walk, Gambler ruins problem and apply Poisson process in real life situations.
3. Formulate and solve problems which involve setting up stochastic models.
4. Understand renewal theory and branching processes with applications

UNIT-I

Markov Chains: Definition, Examples and classification, Discrete renewal equation and basic limit theorem, Absorption probabilities, Criteria for recurrence.

UNIT-II

Continuous time Markov chains, Examples, General pure birth process, Poisson process, Birth and death process, Finite state continuous time Markov chains.

UNIT-III

Galton-Watson branching processes, Generating function, Extinction probabilities, Continuous time branching processes, Extinction probabilities, Branching processes with general variable life time.

UNIT-IV

Renewal equation, Renewal theorem, Applications, Generalizations and variations of renewal processes, Applications of renewal theory, Brownian motion.

Books Recommended:

1. Karlin, S. and Taylor, H.M. (1975) A first Course in Stochastic Processes,second edition, Academic Press.
2. Bhat,B.R.(2002)StochasticProce sses,secondedition,NewAgePublication.
3. Cox, D.R. (1962) Renewal Theory, Methuen.
4. Ross, S. (1996) Stochastic Processes, Second edition, John Wiley.
5. Medhi, **J.**(1994)Stochastic Processes, Second edition, Wiley Eastern.
6. Basu, A.K.(2002)Elements of Stochastic Processes, Narosa Publications.

ST-304 NON-PARAMETRIC METHODS 4 CREDITS

Course Objectives: The learning objectives include:

1. Introduction of the concept of Non normal data and non-parametric distributions.
2. Various non parametric alternatives of the parametric methods and theircharacteristics.

Course Outcomes (CO): After completing this course, students will have clear understanding of

1. Handling data sets which do not have parametric information.
2. Analysing categorical, socio economic, medical and educational data using statistical software package and draw valid statistical inference.

UNIT-I

Empirical distribution function, Gilvenko Cantelli Theorem, Kolmogorov Goodness of fit test.

UNIT-II

One sample U-statistics, kernel and symmetric kernel, two sample U-statistics, asymptotic distribution of U statistics. UMVUE property of U-statistics,

asymptotic distribution of linear function of order statistics.

UNIT-III

Rank tests, locally most powerful rank tests, linear rank statistics and their distributional properties under null hypothesis, Pitman's asymptotic relative efficiency.

UNIT-IV

One sample location problem, sign test and signed rank test, two sample Kolmogorov Smirnov tests, two simple location and scale problems. Wilcoxon-Mann-Whitney test, normal score test, ARE of various tests based on linear rank statistics. Kruskal-Wallis K sample test. Cox's proportional hazards model, rank test (partial likelihood) for regression coefficients, Concepts of jackknifing method of Queenouille for reducing bias, Bootstrap methods.

Books Recommended:

1. Davison, A.C. and Hinkley, D.V. (1997): Bootstrap Methods and TheirApplication, Cambridge University Press.
2. Gibbons, J.D. (1985): Non-Parametric Statistical Inference, 2nd ed. MarcelDekker, Inc.
3. Randles, R.H. and Woffe, D.A. (1979): Introduction to the Theory of Non-Parametric Statistics, John Wiley & Sons, Inc.
4. Fraser. D.A.S. (1957): Nonparametric Methods in Statistics, John Wiley &Sons, Inc.
5. Hajek, J. and Sodal. Z. (1967): Theory of Rank Tests, Academic Pess.
6. Puri, M.L. and Sen, P.K. (1971): Nonparametric Methods of MultivariateAnalysis, John Wiley & Sons, Inc.
7. Cox, D.R. and Oakes, D. (1983): Survival Analysis, Chapman and Hall.

ST-305: STATISTICAL COMPUTING - III: R PROGRAMMING 4 CREDITS

Course Objectives: The learning objectives include:

1. To understand R and its roles in problem solving.
2. To understand data handling and its analysis
3. Learning the basic statistical software will help students to easily switch over toany other statistical software in future.

Course Outcomes (CO): After completing this course, students will have clear understanding of

1. Understand the basic workings of R, and perform basic statistical analyses.
2. To perform descriptive statistics and graphics, and basic inferential statistics for comparisons and correlations using R.
3. Importing data, Code editing in R. This course will review topics in probability and statistics studied in core for data analysis. Introduction to R for statistical computing, analysis and graphical interpretation would be

done using softwareskills. The following problems can be done on any one of the statistical softwareto enhance data analysis skills using software.

UNIT –I

Data types in R: numeric, character, logical; real, integer, complex, strings and the paste command, matrices, data frames, lists, setwd, read. table, read.csv, write. matrix, write.csv, creation of new variables, categorisation, cut, factor;

round, apply, creation of patterned variables, saving output to a file; source; print, saving workspace/history.

Basic Statistics: Frequency distribution, Dot and Bar plot of the given data, Construction of a box plot for the given data. Measures of central tendency, Dispersion.

UNIT-II

Exact Sampling Distributions: Chi-square, t, F, Z.

UNIT-III

Generating function and law of large numbers: Expectation, Test the convergence in probability for given data, central limit theorem and its histogram, test the divergence in probability for given data. Test the convergence in probability for exponential distribution.

UNIT-IV

Survey Sampling: Simple random sampling, Systematic sampling, Ratio & Regression estimation, PPS sampling.

Marks Distribution:

Programming marks	- 80
Viva-voce + Records marks	- 20

Books Recommended

1. Verzani, John. Using R for Introductory Statistics. Taylor & Francis.
2. Yosef Cohen and Jeremiah Y. Cohen. Statistics and Data with R: AnApplied Approach Through Examples. Wiley Publication.

ST-306: STATISTICAL METHODOLOGY 4 CREDITS
Open Elective (IDSE)

Course Objectives: The learning objectives include:

1. Introduction to Statistics.
2. Understanding the nature of data with the help of various statistical tools.
3. Understanding the concept of Probability and probability distributions.

Course Outcomes (CO): After completing this course, students will have clear understanding of

1. The fundamental concepts of statistics

2. Measures of location and dispersion
3. Bivariate data, Significance of various coefficients of correlation
4. Fitting of linear and nonlinear curve
5. Introduction of variables and their pmf, pdf and cdf
6. Discrete and Continuous Probability distributions and its applications
7. Order statistics and their distributions and properties.

UNIT-I

Descriptive Statistics: Measures of central tendency, dispersion, skewness and kurtosis for the study of nature of data. Idea of correlation and regression for two and three variables; correlation coefficient, correlation ratio, multiple and partial correlations.

UNIT-II

Some discrete statistical distributions: Binomial, Poisson, hypergeometric, negative binomial and multinomial distributions. Some continuous distributions (Normal, Uniform, Exponential, Cauchy, Pareto, Weibull, lognormal), Bivariate normal and bivariate exponential distributions and their properties.

UNIT-III

Functions of random variables and their distributions using Jacobian and other tools, convolution and compound distributions, truncated and mixture distributions, Sampling distributions from normal population central and non-central Chi-square, t and F distributions.

UNIT-IV

Order statistics and their distributions and properties. Joint and marginal distributions of order statistics. Extreme values and their asymptotic distribution (statement only) with applications, Asymptotic distribution of median, distribution of quantiles.

Books Recommended:

1. Hogg, R.V. and Craig, A.L. (1978). Introduction to Mathematical Statistics, MacMillan, New York.
2. Mood, A.M., Graybiil, F.A. and Boes, D.C. (2001). Introduction toTheory of Statistics, Tata McGraw Hill, New Delhi.
3. Ross, Sheldon M (2004) Introduction to Probability and Statistics for Engineers and Scientist, Third Edition, Elsevier Academic Press, USA.
4. Rohatgi V.K. and Saleh, A.K.Md. E. (2001). An Introduction to Probability and Statistics (Second Edition), John Wiley and Sons (Asia), Singapore.
5. Dudewicz, E.J. and Mishra, S.N. (1988). Modern MathematicalStatistics, John Wiley, New York.
6. Johnson, S and Kotz, S. (1970). Continuous univariate

Distributions Iand II John Wiley, New York.
7. David, W. S.(2003). Order Statistics (Second Edition). John Wiley andSons, New York.

ST- 401: LINEAR MODELS AND REGRESSION ANALYSIS 4 CREDITS

Course Objectives: The learning objectives include:

1. To develop a deeper understanding of the linear and non-linear regressionmodel and its limitations.
2. To learn how to develop regression model and apply for the specific perspectivedata appropriate manner.

Course Outcomes (CO): After completing this course, students will

1. Apply simple linear regression model to real life examples.
2. Understand multiple linear regression models with applications and concept of Multicollinearity and autocorrelation.
3. Compute multiple and partial correlation and checking residual diagnostic to validate model.
4. Apply Logistic and Non-linear regression models and its implementation in real life situation.

UNIT-I

Regression on the full rank model - methods of estimation and their consequences, distributional properties, general linear hypothesis, testing of common hypothesis and reduced models.

UNIT-II

Regression on dummy variables – regression on allocated codes, regression on dummy (0,1) variables, use of dummy variables on multiple regression.

UNIT-III

Regression models (not of full rank) – consequences and distributional properties. Estimable functions – properties, testing for estimability, general linear hypothesis.

UNIT-IV

Selecting the 'best' regression equation – all possible regressions, backward and forward elimination procedures, step-wise regression procedures. Multiple regression applied to analysis of variance problems – one way and two-way classifications using the models.

Books Recommended

1. Searle, S.R.: Linear Models, John Wiley & Sons
2. Draper, N.R. and Smith, H.: Applied Regression Analysis, John Wiley & Sons.
3. Rao, C.R: Linear Statistical Inference and its Applications, Wiley Eastern Ltd.
4. Kshirsagar, A M: A Course in Linear Models. Marcel Dekker, N. Y.

5. Joshi, D D: Linear Estimation and Design of Experiments. New AgeInternational Publication.
6. Weisberg, S. Applied Linear Regression. Wiley.
7. Chatterjee, S. and Price, B: Regression Analysis by Example. John Wiley,New York.

ST-402: ECONOMETRICS 4 CREDITS

Course Objectives: The aim of this course is:

1. To judge the validity of the economic theories
2. To carry out evaluation of economic theories in numerical terms.
3. To extract useful information about important economic policy issues from theavailable data.

Course Outcomes (CO): After completing this course, students will have clear understanding of

1. The fundamental concepts of econometrics.
2. Specification of the model.
3. Simple Linear Regression & Multiple Linear Regression with their uses.
4. Multicollinearity , Heteroscedasticity and their applications.

UNIT-I

Nature of econometrics, ordinary least squares (OLS)estimation and prediction, Multicollinearity- detection, consequences and remedial measures.

UNIT-II

The general linear model (GLM) and its extensions, generalized least squares (GLS) estimation (Aitken estimators) and prediction, heteroscedastic disturbances–nature, OLS estimators in the presence of heteroscedasticity, detection, consequences and remedial measures.

UNIT-III

Simultaneous equation models – examples, the simultaneous-equation bias. Identification problem – concepts and definitions, under, just or exact and over identifications, rules for identification, test of simultaneity, restrictions on structural parameters, rank and order conditions.

UNIT -IV

Simultaneous equation methods – approaches to estimation, recursive systems, method of indirect least squares (ILS), method of two-stage least squares (2SLS), full information maximum likelihood method, prediction and simultaneous confidence intervals.

Books Recommended

1. Johnston, J.: Econometric Methods, McGraw-Hill
2. Gujarati, D.: Basic Econometrics, McGraw-Hill.
3. Theil, H.: Introduction to the Theory and Practice of Econometrics, JohnWiley.
4. Apte, P.G.: Text Book of Econometrics, Tata McGraw-Hill.
5. Cramer, J.S.: Empirical Econometrics, North Holland.
6. Maddala, G.S.: Econometrics, McGraw-Hill.

OR

ADVANCED SURVEY SAMPLING METHODS

UNIT-I

Unequal probability sampling with replacement – probability proportional to size with replacement sampling, estimation of mean/total, method of selection, standard error of estimate and it's estimation, comparison with SRSWR, gain due to PPSWR sampling, optimum size measure, estimator based on distinct units in PPSWR sampling

UNIT-II

Unequal probability sampling without replacement – Des Raj's ordered estimator, Murthy's unordered estimator, Horvitv-Thompson estimator and it's optimal properties. Midzuno, Narain, Brewer, Durbin, Sampford, and Rao-Hartly-Cochransampling procedures, systematic sampling with varying probabilities.

UNIT-III

Multi-phase Sampling – double sampling for ratio and regression methods, stratification and PPS sampling. Sampling on two and more occasions.

UNIT-IV

Errors in surveys – types of errors, mathematical models for measurement error.Problems of non-response – Hansen and Hurwitz technique, Politz-Simon technique. Randomized response techniques – Warner's model and unrelated question model. Variance estimation – methods of random groups, the Jack knife, balanced half sample, and the bootstrap. Small area estimation – direct, synthetic and composite estimators.

Books Recommended

1. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C.: Sampling Theory of Surveys with Applications, Indian Soc. of Agric. Stat., New Delhi
2. Cochran, W. G: Sampling Techniques. Wiley Eastern.
3. Murthy, M. N: Sampling Theory and Methods. Statistical Publishing Society.
4. Mukhopadhyay, Parimal: Small Area Estimation in Survey Sampling. Narosa Publising House.

Or

ADVANCED DESIGN & ANALYSIS OF EXPERIMENT

UNIT-II

Analysis of fixed effects model: Estimation of model parameters, Unbalanced data, Model adequacy checking, Practical interpretation of results, determinationof sample size.

UNIT-III

Factorial experiments with mixed levels: Factors at two and Three levels, factors at two and four levels, Constructing Fractional Factorial Designs using an Optimal design tool.

UNIT-IV

Response surface designs – linear response surface designs, second order response surface designs. Experimental designs for fitting response surfaces, Mixture experiments. Rubust Design: Introduction, Crossed array designs and analysis, Combined array designs and the response model approach, Choice of designs

Books Recommended:

1. Montgomery, D.C. (2014): Design and Analysis of Experiments, Eighthedition, Wiley, NY
2. Dey, A.: Theory of Incomplete Block Designs, Wiley Eastern.
3. Das, M.N. and Giri, N.: Design and Analysis of Experiments, New AgeInternational.
4. Kempthorne, O. (1952): The Design and Analysis of Experiments, Wiley,NY.
5. Chakrabarty, M.C.: Mathematics of Design of Experiments. Asian pub.House.
6. Khuri, A. and Cornell, M.: Response Surface Methodology. Marcel Dekker.

Or

ADVANCED OPERATIONS RESEARCH

UNIT-I

Dynamic programming: Basic concepts, development of dynamic programming, continuous state dynamic programming, multiple state variables, Goal programming: categorization, formulation, graphical goal attainment method, simplex method.

UNIT - II

Fuzzy logic: Fuzzy relations, fuzzy systems, defuzzification methods, Non-Linear programming: Unconstrained optimization, constrained optimization: Equality constraints and inequality constraints.

UNIT-III

Simulation Modeling: examples, pseudo-random numbers, techniques for generating for random deviates, simulation languages, advanced concepts in simulation analysis: Design of simulation experiments, variance reduction techniques, statistical analysis of simulation output, optimization of simulation parameters.

UNIT-IV

Integer programming: Pure and mixed integer programming problem, Gomory's all integer programming problem, Gomory's constraints, fractional cut method: all integer and mixed integer, Branch and Bound algorithm.
Network routing problems: Minimal spanning tree, shortest route algorithm, maximal flow problems, minimum cost flow, Resource analysis in network scheduling: Project cost, time cost optimization algorithm, linear programming formulation, updating, resource allocation and scheduling.

Books Recommended:

1. Hardly, G. (1964): Non-linear and Dynamic Programming, AddisonWesley
2. Wagner, H.M. (1969): Principles of Operations Research withApplications to Managerial Decisions, Prentice Hall
3. Ravindran, A., Phillips, D.T. and Solberg, J.J. (2009): OperationsResearch: Principles and Practice, Wiley-India.
4. Zimermann, H.J. (2001): Fuzzy Set Theory and its Applications, 2nd ed.,Allied Publishers.
5. Lee, K.H. (2006): Fuzzy logic and Its Applications, Springer.
6. Rajasekharan, S. and Pai, G.A.V. (2006): Neural Networks, Fuzzy Logicand Genetic Algorithms, PHI.

ST-403: TIME SERIES AND STATISTICAL QUALITY CONTROL 4 CREDITS

Course Objectives: The learning objectives include:

1. The main purpose is to teach the time series modelling and the concept offorecasting and future planning.

2. To help students understand the concepts underlying statistical quality control and to develop their ability to apply those concepts to the design and management of quality control processes in industries.

Course Outcomes (CO): After completing this course,

1. Students will be acquainted with different time series models such as MA, AR, ARMA and ARIMA models.
2. They will learn of models for forecasting purpose. The emphasis will be

on ensuring that the students gain both a broad perspective of quality control as well as the technical skills necessary to implement quality control in anyindustrial setting.

UNIT-I

Time series as discrete parameter stochastic process. Auto covariance and autocorrelation function and their properties. Exploratory Time Series Analysis, Tests for trend and Seasonality. Exponential and Moving Average Smoothing, Holt and Winters smoothing. Forecasting based on smoothing, Adaptive smoothing.

UNIT-II

Detailed study of the stationary processes: (1) moving average (MA), (2) Auto regressive (AR)., (3) ARMA and (4) AR integrated MA (ARIMA) models, Box Jenkinsmodels, Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory, Choice of AR and MA periods. Estimation of ARIMA model parameters.

UNIT-III

Industrial statistics $\bar{X}, R$tistical quality control, need for statistical quality control, control charts in general, random and assignable causes, purpose of control charts, process control, control charts for measurements, charts for averages, attributes, defectives and defects, CUSUM chart, V-Mask technique, economic design of Charts.

UNIT-IV

Acceptance sampling plans – single and double sampling plans for attributes, Five curves and their importance, producer's and consumer's risk, variable sampling plans, sequential sampling plans. Sequential probability ratio test- OC and ASN functions, sequential tests for testing means of normal and binomial populations. Tolerance and Specification limits, Capability indices. Estimation, confidence intervals and tests of hypotheses relating to capability indices for normally distributed characteristics.

Books Recommended:

1. Box, G.E.P., Jenkins, G. M. and Reinsel, G. C.: Time Series Analysis,Pearson Edition
2. Burr, I.W.: Engineering Statistics and Quality Control, McGraw-Hill
3. Grant, E.L. and Leavenworth, R.S.: Statistical Quality Control, McGraw-Hill.
4. Anderson, T.W. (1971). The Statistical Analysis of Time Series, Wiley, N.V.
5. Montgomerv, D.C. (1985) Introduction to Statistical Quality Control:Wiley
6. Wetherill, G.B. and Brown, D.W. Statistical Process Control. TheoryandPractice: Chapman and Hall

OR

RELIABILITY THEORY

Unit-I

Reliability concepts and measures; components and systems; coherent systems; Reliability of coherent system; cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components.

UNIT-II

Life distributions; reliability function; hazard rate; common life distributions – exponential, Weibull, gamma, normal, bivariate exponential, etc.; Estimation of parameters and tests in these models.

UNIT-III

Notions of aging; IFR; IFRA; NBU; DMRL and NBUE classes and their duals; loss of memory property of the exponential distribution; closures of these classes under formation of coherent systems; partial ordering of life distributions, convolution and mixtures.

UNIT-IV

Reliability estimation based on failure times from variously censored life-tests data for parametric families, stress-strength reliability and its estimation. Kaplan – Meier estimation of reliability curve, Greenwood formula, Non – parametric methods for comparison of several reliability curves, Log rank tests. Regression models in reliability, Cox PH and Accelerated failure time models; Estimation of parameters and diagnostics.

Books Recommended:

1. Barlow, R.E. and Proschan, F. (1985): Statistical Theory of Reliability andLife Testing; Holt, Rinehart and Winston.
2. Lawless, J.F. (1982): Statistical Models and Methods of Life Time Data;John Wiley.
3. Nelson, W. (1982): Applied life Data Analysis; John Wiley.
4. Zacks, S.: Reliability Theory; Springer
5. Bain, L. J. and Engelhardt (1991): Statistical Analysis of Reliability and LifeTesting Models; Marcel Dekker.
6. Kalbfleisch, J.D. & Prentice R.L.: The Statistical Analysis of Failure timedata, 2nd ed.
7. Lai, C.D.&Xie, M.: Stochastic Ageing and Dependence for Reliability

8. Gertsbakh, I.B.: Reliability Theory with Applications to preventivemaintenance

ST-404: OFFICIAL STATISTICS 4 CREDITS

Course Objectives:
Basic concepts of Statistics, Role of statistics in Science, Society, and for National Development, Descriptive statistics. Scope of population census of India, System of collection of Agricultural Statistics.

Course Outcomes (CO): After successful completion of this course, students are expected to:

1. Acquire knowledge of statistics and its scope and importance in various areas such Agricultural and Social Science, Finance etc.

2. Know information about various Statistical Organizations in India and their functions for societal developments. Knowledge of various types of data, their organization and evaluation of summary measures such as measures of central tendency and dispersion, etc.

3. Insights into preliminary exploration of different types of data.

UNIT-I
Introduction to Indian and International statistical systems, Role, function and activities of Central and State statistical organizations. Organization of large-scale sample surveys. Role of National Sample Survey Office. General and special data dissemination systems.

UNIT-II
Population growth in developed and developing countries, evaluation of performance of family welfare programmes projections of labour force and manpower. Scope and content of population census of India.

UNIT-III
Estimation of national income-product approach, income approach and expenditure approach.

UNIT-IV
System of collection of Agricultural Statistics. Crop forecasting and estimation, Productivity, fragmentation of holdings, support process, buffer stocks, impact of irrigation projects. Statistics related to industries.

Books Recommended:

1. Basic Statistics Relating to the Indian Economy (CSO) 1990.

2. Guide to Official Statistics (CSO) 1999.
3. Statistical System in India (CSO 1995.
4. Principles and accommodation of National Population Censuses, UNESCO.
5. Panse, V.G., Estimation of Crop Yields (FAO)
6. Family Welfare Yearbook. Annual Publications of D/o Family Welfare.
7. Monthly Statistics of foreign Trade in India, DGCIS, Calcutta and otherGovt. Publication.

OR

ACTURIAL STATISTICS

UNIT-I

Mortality – mortality experience, mortality table, graph of Lx, force of mortality, laws of mortality, mortality table as a population model, expectation of life, stationary funds.

UNIT-II

Annuities – pure endowments, annuities, accumulations, assurances, varying annuities and assurances, continuous annuities, family income benefits.

UNIT-III

Policy values – nature of reserve, prospective and retrospective reserves, fractional premiums and fractional duration, modified reserves, continuous reserves, surrender values and paid up policies, industrial assurance, children's deferred assurances, joint life and last survivorship.

UNIT-IV

Contingencies - contingent probabilities, contingent assurances, reversionary annuities, multiple decrement table, forces of decrement, construction of multiple decrement table.

Pension funds – capital sums on retirement and death, widow's pension, sickness benefits, benefits dependent on marriage.

Books Recommended:

1. Dickson, C. M. D. (2005): Insurance Risk and Ruin (International Series OnActuarial Science), Cambridge University Press.
2. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A. And Nesbitt, C. J.
(1997): Actuarial Mathematics, Society of Actuaries, Itasca, Illinois, U.S.A.

OR

QUANTITATIVE EPIDEMIOLOGY

UNIT-I

Introduction to epidemiology, causation, prevention and communicable diseasesin epidemiology. Clinical environmental and occupational epidemiology.

UNIT-II

Epidemiologic measures - organizing and presenting epidemiologic data, measures of disease frequencies, relative risk and odd ratio, attributable risk.

UNIT-III

Analysis of epidemiologic studies – adjustment of data without uses of multivariate model, direct and indirect adjustments. Confounding variables in 2X2 tables, confident limits for adjusted odd ratios, multiple match controls.

UNIT-IV

Regression model, adjustment using multiple regression and multiple logistic models, survival over several intervals, withdrawals, life table for specific causes, comparison of complete survival curves. Product limits, Cox regression. Epidemiology of infectious and chronic diseases, epidemiology and cancer prevention. Environmental epidemiology, molecular and genetic epidemiology.

Books Recommended:

1. K. J. Rothman and S. Geenland (ed.) (1998). Modern Epidemiology,Lippincott-Raven.
2. S. Selvin (1996). Statistical Analysis of Epidemiologic Data, Oxford University Press.
3. D. McNeil (1996). Epidemiological Research Methods. Wiley and Sons.
4. J. F. Jekel, J. G. Elmore, D.L. Katz (1996). Epidemiology, Biostatisticsand Preventive Medicine. WB Saunders Co.

OR

SURVIVAL ANALYSIS AND CLINICAL TRIALS

UNIT-I

Concept of time, order, Type I, Type II and progressive or random censoring with biological examples, Functions of survival time, hazard function, survival distributions and their applications viz. exponential, gamma, Weibull, Rayleigh, lognormal, Pareto death density function for a distribution having bath-tub shape hazard function.

UNIT-II

Life tables, mean residual life, Non-parametric methods for estimating survival function and variance of the estimator viz. Actuarial and Kaplan – Meier methods. Estimation under the assumption of IFR/DFR. Two sample problem–Gehan test, log rank test.

UNIT-III

Semi-parametric regression for failure rate– Cox's proportional hazards model with one and several covariates, rank test for the regression coefficient, Competing risk model. 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, multi-centre trials, Single and double blinding.

UNIT-IV

Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. Longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of phase III trials with sequential stopping.

Books Recommended:

1. Kalbfleisch J. D. and Prentice R. (1980): The Statistical Analysis of failureTime data, John Wiley.
2. Kleinbaum, D.G. (1996): Survival Analysis, Springer
3. Lee, Elisa, T. (1992). Statistical Methods for Survival Data Analysis, JohnWiley & Sons.
4. Miller, R.G. (1981). Survival Analysis, John Wiley & Sons.
5. Piantadosi. S. (1997): Clinical Trials: A Methodologic Perspective. Wiley andSons.
6. Friedman, L. M. Furburg, C. Demets, D. L. (1998): Fundamentals of Clinical Trials. Springer Verlag.
7. Marubeni. E. and Valsecchi. M. G. (1994): Analyzing Survival Data fromClinical Trials and Observational Studies, Wiley and Sons.

OR

BIG DATA ANALYTIC TECHNIQUES

UNIT-I

Resampling Techniques: Introduction to Jackknife and Bootstrap-methods for estimating bias, standard error and distribution function based on id random variables, standard examples, Bootstrap confidence intervals.

UNIT-II

Missing data analysis: Informative or non-informative missingness; complete case / available case estimation.

UNIT-III

Missing data analysis: Imputation, EM & MCEM algorithms and data augmentation techniques. Standard error estimation.

UNIT-IV

Longitudinal data analysis: Longitudinal regression: Cohort vs longitudinal effect, Weighted least-squares, ML and REML techniques. Marginal, subject specific and transition models, GEE.

Books Recommended:

1. J.J. Faraway: Linear Models with R
2. J.J. Faraway: Extending the Linear Model with R
3. D. Ruppert et al.: Semiparametric Regression
4. R.J.A. Little & D.B. Rubin: Statistical Analysis with Missing Data
5. C.K. Enders: Applied Missing Data Analysis
6. M.A. Tanner: Tools for Statistical Inference
7. G.J. McLachlan & T. Krishnan: The EM Algorithm and Extensions
8. B. Efron & R.J. Tibshirani: An introduction to bootstrap
9. B. Efron: The jackknife, the bootstrap, and other resampling plans
10. B. Efron: Bootstrap methods – another look at jackknife
11. J. Shao & D. Tu : The Jackknife and Bootstrap
12. P.J. Diggleet. al.: Analysis of Longitudinal Data

(2nd ed).13.

ST- 405: PROJECT W ORK AND SEMINAR PRESENTATION 4 CREDITS

The supervisors are to be allotted to the students before the end of third semester examination and they have to prepare a seminar paper and also a project paper under his/her guidance.

Internal Examination: 30 Marks

Seminar Presentation: 20 Marks & *Project paper Presentation before the Supervisor:10 Marks.*

Each student has to give one seminar presentation before the students and faculties on any area of Statistics with his/her interest carrying 20 Marks. This mark will be the average mark given by the faculties of the department attending the presentation.

The project paper is to be presented before the Department Research Committee (DRC) in the presence of their respective supervisor before final presentation and it carries 10 Marks.

Project Evaluation: 70 Marks