

P. G. SEMESTER EXAMINATION REGULATIONS

CHAPTER – I

REGULATION OF GENERAL ACADEMIC MATTERS

1.1 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.

1.1.1 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.

1.1.2 Semester

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

1.2 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

1.3 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 teaching hour of theory class will be of 60 minutes 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.

1.4 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.

1.4.1 Grade

The grade awarded to a student in any particular course shall be based on his/her performance in all 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 to 10.00 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 is required 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.

1.4.2 Grade Point Average (G.P.A.)

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

$$GPA = \frac{\sum A \times B}{C}$$
, where A = Credits in each course, B = Grade point in that course & C = 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.

1.4.3 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.

1.4.4 Conversion of grades to marks and classification of results under course credit system

The 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 in the following manner:

O.G.P.A. > 6.0	: FIRST CLASS
O.G.P.A. > 5.0 - < 6.0	: SECOND CLASS
O.G.P.A. >4.0 - < 5.0	: THIRD CLASS
O.G.P.A. < 4.0	: FAIL

1.5 Academic Calendar

The Examination Section and the academic section shall finalise the schedule of semester registration and other academic activities at the start of academic session. The Academic 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 for Ist Semester	JULY
1 st Semester Examination	DECEMBER
Commencement of Classes for 2 nd Semester	JANUARY-MAY
2 nd Semester Examination	JUNE
Commencement of 3 rd Semester Classes	JULY-NOVEMBER
3 rd Semester Examination	DECEMBER
Commencement of 4 th Semester Classes	JANUARY-APRIL
4 th Semester Examination	APRIL & MAY
Final Results to be published in the month of	JUNE

1.5.1 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.

1.6 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.

1.7 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

2.1 *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.

2.2 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 marks for term end and 10 marks for Mid Term. 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.

2.3 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.

2.4 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.

2.5 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 death of 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 deposes him/her

2.6 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 the semester 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.

2.7 Award of Degree Certificate, Grade/Mark sheet

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.

2.8 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.

2.9 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.

2.10 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 inconvenience to other students in the examination hall or near about shall be treated as adoption of unfair means or malpractice.

Sd/-
REGISTRAR

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 and Distributions-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 and Distributions -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

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

DETAILED SYLLABUS

SEMESTER - I

ST-101 MATHEMATICAL ANALYSIS AND LINEAR 4 Credits **ALGEBRA**

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. Apostol, 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

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., Graybiel, 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. Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics, John Wiley, New York.
6. Johnson, S and Kotz, S. (1970). Continuous univariate Distributions I and II John Wiley, New York.

7. David, W.S. (2003). Order Statistics. (Second Edition). John Wiley and Sons, New York.

ST-103 PROBABILITY THEORY AND DISTRIBUTIONS-I 4 Credits

UNIT-I

Sequence of sets, limsup, liminf and limit of sequence of sets, classes of sets, field, sigma field, minimal sigma field, Borel sigma field, set functions. Measure and its properties, measurable functions and inverse functions. Probability measure, sample space, probability axioms, properties of probability, conditional probability, Bayes' theorem, independence of events.

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-Johnson.

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 and Mathematical Statistics, Wiley Eastern.
7. Billingsley, P. (1986): Probability and Measure, John Wiley Publications.

ST-104

STATISTICAL INFERENCE-I

4

Credits

UNIT 1

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. Mukhopadhyay, P (1999) Mathematical Statistics, New Central Book Agency Pvt. Ltd.
6. Hogg, R.V. and Craig, A.T. (1971): Introduction to Mathematical Statistics, Princeton University Press.

ST-105 STATISTICAL COMPUTING-I USING SPSS 4 Credits

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, Duxbury Press

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 & DISTRIBUTIONS – II 4 Credits

UNIT-I

Non-central chi-square, t and F distributions. Bivariate normal and bivariate hypergeometric distributions. Exponential family of distributions.

UNIT-II

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

Characteristic function – definition and properties, inversion theorem, uniqueness theorem, characteristic function and moments. Convergence of distribution function and characteristic function. Helly-Bray theorem, Extended Helly-Bray theorem, continuity theorem, Borel-Cantelli lemma.

UNIT-IV

Laws of large numbers – Chebyshev's, Khinchin's, and Bernoulli's laws of large numbers. Hajek-Reni and Kolmogorov inequalities (statements only) and Kolmogorov's strong law of large numbers. Central limit theorem – Lindberg –Levy and Liapounov forms with proofs and applications. Lindberg-Feller form (without proof).

1. Rohatgi, V.K. and Ehsanes Saleh, A.K.M.: An Introduction to Probability and 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, Vol I. John Wiley.

ST- 202

STATISTICAL INFERENCE-II

4 Credits

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 Publishing House
2. Rohatgi, V.K. and Ehsanes Saleh, A.K.M.: An Introduction to Probability and 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

UNIT-I

Basic concepts of finite population and sampling techniques. An outline of fixed-population and super-population approaches, distinctive features of finite population sampling, sampling designs, Methodologies in sample surveys (questionnaires, sampling design and methods followed in field investigation) by NSSO, 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, non-negative variance estimation with reference to the Horvitz-Thompson estimator.

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, Multivariate ratio estimator (Olkin's estimator), Double sampling. Errors in surveys – Unit and item non-response, effect of unit non-response on the estimate, methods of studying non-response (call back, without callback and imputation), non-sampling errors, Warner's randomized response technique.

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 Publishing House.
5. Mukhopadhyay, Parimal: Theory and Methods of Survey Sampling. Prentice Hall.
6. Murthy, M. N: Sampling Theory and Methods. Statistical Publishing Society.

ST-204

OPERATIONS RESEARCH

4 Credits

UNIT-I

Definition and Scope of Operations Research: Phases in Operation Research, models and their solutions 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. Zimmermann, 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

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.

Text Books:

1. E. Balagurusamy, "Programming in ANSI C", 4/e, (TMH)

Reference Books:

1. B. Kernighan & Dennis Ritchie, "The C Programming Language", 2/e PHI
2. Paul Deitel, Havery Deitel, "C: How to Program", 8/e, Prentice Hall.

Marks Distribution:

ST- 206 (DSE) DEMOGRAPHY& VITAL STATISTICS 4 CreditsUNIT-I

Coverage and errors in demographic data, Chandrasekharan Deming formula. Adjustment of age data, Whipples, 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 Merrell, 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 Gompertz 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, Himalayan Publishers

2. Srinivasan, K.: Basic Demographic Techniques and Applications, Sage Publishers
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

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

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, (4th ed.), World Press.
4. Dey, Alope: Theory of Block Designs. New Age International.
5. Dean, Angela and Voss, Daniel: Design and Analysis of Experiments. New Age International.
6. Chakrabarty, M.C. : Mathematics of Design of Experiments. Asian pub. House.

7. Montgomery, C.D.: Design and Analysis of Experiments. John Wiley, New York.

ST-C- 303

STOCHASTIC PROCESSES

4 Credits

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) Stochastic Processes, second edition, New Age Publication.
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

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 sample 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 Their Application, Cambridge University Press.
2. Gibbons, J.D. (1985): Non-Parametric Statistical Inference, 2nd ed. Marcel Dekker, 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 Press.
6. Puri, M.L. and Sen, P.K. (1971): Nonparametric Methods of Multivariate Analysis, 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

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	- 80 marks
Viva-voce + Records	- 20 marks

Books Recommended

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

ST-306 Open Elective (IDSE) STATISTICAL METHODOLOGY 4 Credits

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 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. Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics, John Wiley, New York.
6. Johnson, S and Kotz, S. (1970). Continuous univariate Distributions I and II John Wiley, New York.
7. David, W.S. (2003). Order Statistics. (Second Edition). John Wiley and Sons, New York.

ST- 401 LINEAR MODELS AND REGRESSION ANALYSIS 4 Credits

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 Age International 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

UNIT-I

Nature of econometrics, ordinary least squares (OLS) estimation and prediction, 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, pure and mixed estimation.

UNIT-II

Autocorrelation-Nature and reasons of autocorrelation, OLS estimation in the presence of autocorrelation, its consequences and tests. Theil BLUS procedure, estimation and prediction, Multicollinearity- detection, consequences and remedial measures, Linear regression and stochastic regression, autoregressive linear regression.

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, John Wiley.
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

ST-402

ADVANCED SURVEY SAMPLING METHODS

4 Credit

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 its 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, Horvitz-Thompson estimator and its optimal

properties. Midzuno, Narain, Brewer, Durbin, Sampford , and Rao-Hartly-Cochran sampling 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 Publishing House.

OR

ST -402 ADVANCED DESIGN& ANALYSIS OF EXPERIMENT 4 Credits

UNIT-I

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

UNIT-II

Two-Level Fractional Factorial Designs: The one-half fraction of the 2^k Design, one-quarter fraction of the 2^k Design, the general 2^{k-p} Fractional Factorial Design, Alias structure.

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. Robust 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, Eighth edition, 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 Age International.
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

ST- 402

ADVANCED OPERATIONS RESEARCH

4 Credits

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. Hardy, G.(1964): Non-linear and Dynamic Programming, Addison Wesley
2. Wagner, H.M.(1969): Principles of Operations Research with Applications to Managerial Decisions, Prentice Hall
3. Ravindran, A., Phillips, D.T. and Solberg, J.J. (2009): Operations Research: Principles and Practice, Wiley-India.
4. Zimmermann, 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 Logic and Genetic Algorithms, PHI.

ST-403 TIME SERIES AND STATISTICAL QUALITY CONTROL 4 Credits

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 Jenkins models, 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 – statistical 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 \bar{X}, R 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. Theory andPractice: Chapman and Hall

OR

ST-403

RELIABILITY THEORY

4 Credits

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 and Life 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 Life Testing Models; Marcel Dekker.
6. Kalbfleisch, J.D. & Prentice R.L. :The Statistical Analysis of Failure time data, 2nd ed.
7. Lai, C.D.&Xie, M. :Stochastic Ageing and Dependence for Reliability
8. Gertsbakh, I.B. :Reliability Theory with Applications to Preventive maintenance

ST-404

OFFICIAL STATISTICS

4 Credits

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 other Govt. Publication.

OR

ST- 404

ACTUARIAL STATISTICS

4 Credits

UNIT-I

Mortality – mortality experience, mortality table, graph of L_x , 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 On Actuarial 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

ST- 404

QUANTITATIVE EPIDEMIOLOGY

4 Credits

UNIT-I

Introduction to epidemiology, causation, prevention and communicable diseases in 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 use of multivariate model, direct and indirect adjustments. Confounding variables in 2×2 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. Greenland (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, Biostatistics and Preventive Medicine. WB Saunders Co.

OR

ST- 404 SURVIVAL ANALYSIS AND CLINICAL TRIALS 4 Credits

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, Multicenter 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 failure Time data, John Wiley.
2. Kleinbaum, D.G. (1996): Survival Analysis, Springer
3. Lee, Elisa, T. (1992). Statistical Methods for Survival Data Analysis, John Wiley & Sons.
4. Miller, R.G. (1981). Survival Analysis, John Wiley & Sons.
5. Piantadosi. S. (1997): Clinical Trials: A Methodologic Perspective. Wiley and Sons.
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 from Clinical Trials and Observational Studies, Wiley and Sons.

OR

ST- 404

BIG DATA ANALYTIC TECHNIQUES

4 Credits

UNIT-I

Resampling Techniques: Introduction to Jack-knife 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. Et al.: Analysis of Longitudinal Data (2nd ed).

ST- 405 PROJECT WORK 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 before final presentation is to be presented before their supervisor and it carries 10 Marks.

Project Evaluation: 70 Marks