चौधरी चरण सिंह विश्वविद्यालय, मेरठ

2003-04 एवं आगे के वर्षों के लिए
पाठ्यक्रम - सार्थिकी

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विश्वविद्यालय अनुदान आयोग के निर्देशानुसार
eवं पाठ्यचर्चा के आधार पर तैयार किया गया पाठ्यक्रम

— मुद्रक —
कुलसचिव, चौधरी चरण सिंह विश्वविद्यालय, मेरठ

जौलाई - 2003
REQUIREMENTS / RECOMMENDATIONS

1. Eligibility for admission to M.A. / M.Sc. (Statistics) should be B.A. / B.Sc. with Mathematics as one main subject.

2. That there are four practical examinations (2 in M.Sc. Previous and 2 in M.Sc. – Final). Each of these four practicals should be conducted by different examiners. This is necessary because these are based on separate courses and only the experts of these courses should conduct the examinations.

3. That at least one extra hand (preferably with computer knowledge) be provided to meet out the additional work load created due to increased syllabus and addition of computer course.

4. Each department of statistics be equipped with sufficient number of computers to enable the students to carry out their practical work.

5. Each department of statistics must have one lab. Assistant with knowledge of computers to assist the practical work in lab.

6. That the theory question papers should be moderated through the moderation board to be chaired by the convener of the board of studies.

7. Some new topics have been included in the revised syllabus and therefore it is necessary that some sort of training be imparted to the teaching staff probably the form of orientation / refresher courses.

8. Use of electronic calculators is allowed in all theory papers as well as practical exams.
# B.Sc. (Statistics)

w.e.f. (2003-04)

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Title</th>
<th>Teaching per week</th>
<th>Exam. Duration Hrs.</th>
<th>Marks</th>
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<td>Hrs.</td>
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<tr>
<td>IV</td>
<td>Sample Survey &amp; Analysis and Design of Experiments</td>
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<td>4</td>
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<tr>
<td>V</td>
<td>Applied Statistics</td>
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<td>4</td>
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<tr>
<td>VI</td>
<td>Computational Techniques</td>
<td>3</td>
<td>4</td>
<td>3</td>
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<tr>
<td>P-3</td>
<td>Practical (per batch)</td>
<td>4</td>
<td>6</td>
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</table>

* One period of 45 minutes duration.

* Use of Electronic Calculator is allowed in every paper.

* Batch consist of 20 (twenty) students.
B.Sc.-I

COURSE-I

DESCRIPTIVE STATISTICS

Unit 1:
Types of Data: Concepts of a statistical population and sample from a population; qualitatively and quantitative data; nominal and ordinal data; cross sectional and time series data; discrete and continuous data; frequency and non-frequency data. Different types of scales – nominal, ordinal, ratio and interval.

Collection and Scrutiny of Data: Primary data – designing a questionnaire and a schedule; checking their consistency. Secondary data – its major sources including some government publications. Complete enumeration, controlled experiments, observational studies and sample surveys. Scrutiny of data for internal consistency and detection of errors of recording. Ideas of cross-validation.

Presentation of Data: Construction of tables with one or more factors of classification. Diagrammatical and graphical representation of grouped data. Frequency distributions, cumulative frequency distribution and their graphical representation, histogram, frequency polygon and ogives. Stem and leaf chart. Box plot.

Unit 2:
Analysis of Quantitative Data: Univariate data-Concepts of tendency or location, dispersion and relative dispersion.

Unit 3:
Skewness and kurtosis, and their measures including those based on moments. Sheppard’s corrections for moments for grouped data (without derivation). Principles of least squares, fitting of polynomial curves & fitting of curves reducible to polynomial form.

Unit 4:

Multivariate data: Multiple regression, multiple correlation and partial correlation in three variables, their measures and related results.

Unit 5:
Analysis of Categorical Data: Consistency of categorical data. Independence and association of attributes. Various measures of association for two – way and three-way classification data.

Note: Use of Electronic Calculators is allowed
COURSE - II

PROBABILITY THEORY

Unit 1:
Random Experiment: Trial, sample point and sample space, definition of random events, algebra of events, mutually exclusive, equally likely and exhaustive events. Important concepts: probability, classical and relative frequency definitions of probability, their merits and demerits. Axiomatic approach to probability, simple properties of probability based on axiomatic approach, conditional probability, independence of events, Bayes' Theorem and its applications.

Unit 2:
Discrete and continuous random variables, probability mass function and probability density function, jointly distributed random variables, joint marginal and conditional probability and density function, independence of random variables.

Expectation of a random variable, its properties, measures of location, dispersion and moments variance of linear combination of random variables, covariance, correlation coefficient of two random variables.

Unit 3:
Moment generating function (mgf) and cumulant generating function and their additive property for independent random variables. Characteristic function: definition, properties, uniqueness and inversion theorems (statement only), Chebyshev's inequality (statement and applications) of weak, law of large numbers and central limit theorem (for iid variables only).

Unit 4:
Discrete univariate distributions: Uniform, Bernoulli, Binomial, Poisson, Hypergeometric and Negative Binomial distributions, fitting of Binomial and Poisson distributions.

Unit 5:
Continuous univariate distributions: Uniform, Exponential, Beta and Gamma distributions and their simple properties, Normal distribution, its properties and its fitting.

Note: Use of Electronic Calculators is allowed.
PRACTICAL-1

The following topics are prescribed for practical work:

1. Graphical representation of data by:
   (i) Histogram
   (ii) Frequency Polygon
   (iii) Frequency Curve
   (iv) Ogive

2. Diagrammatic representation of data by:
   (i) Bars
   (ii) Circles
   (iii) Squares

3. Computation of:
   (i) Mean, Median, Mode, G.M., H.M. and partition values
   (ii) Range, Standard Deviation, Mean Deviation, Quartile Deviation and Coefficient of variation.
   (iii) Moments, β & γ coefficients.
   (iv) Coefficient of correlation and Rank correlation.

4. Fitting and plotting of regression lines.

5. Fitting by the method of least squares:
   (i) Straight line
   (ii) Second degree parabola
   (iii) Exponential Curve
   (iv) Logarithmic Curve

6. Fitting of Distributions:
   (i) Binomial
   (ii) Poisson
   (iii) Normal

Note: Use of Electronic Calculators is allowed.
COURSE- III

B.Sc.-II

INFERENCE

Unit 1:
Estimation – Concept of statistic and its sampling distribution, Point estimate of a parameter, Criteria of good estimator, unbiasedness, consistency, efficiency and sufficiency with simple illustrations only.

Unit 2:
Point estimation, maximum likelihood method and the application of this method for obtaining estimates of the parameters of the Binomial, Poisson and Normal distributions and in other simple cases also, properties of m.l.e. without proof. Method of moments and its applications.

Interval estimation – concept of interval estimation and its derivation in simple cases.

Unit 3:
Testing of Hypothesis – Null and alternative hypothesis, simple and composite hypothesis, two types of errors, level of significance, concept of power and power function, critical region and acceptance region, Neyman Pearson’s lemma and its application to find the best critical region for a simple hypothesis in the case of Binomial, Poisson, Normal and some other simple distributions.

Unit 4:
Testing of Significance – Large sample test for proportion and means: (i) single sample (ii) two independent samples. t, F and chi-square distributions and their simple properties (without proof). Small sample tests based on t, F and chi-square distributions.

Unit 5:
Non-Parametric Methods – Distinction between parametric and non-parametric tests, advantages of non-parametric tests, simple notions of sign test, median test, Wilcoxon test and run test with examples. Kolmogrove-Smirnov test for goodness of fit.

Note:- Use of Electronic Calculators is allowed.
COURSE- IV

SAMPLE SURVEY & ANALYSIS AND DESIGN OF EXPERIMENTS

Unit 1:
Sampling Method: Concept of population, sample, parameter and statistic, sampling versus census, advantages of sampling methods, role of sampling theory, sampling and non-sampling errors, Bias and its effects, probability sampling.

Unit 2:
Simple random sampling with and without replacement. Estimation of population total and population mean; variance and standard error of the estimates.

Unit 3:
Stratified Sampling: Introduction, principles of stratification, advantages and uses of stratified sampling. Notation and terminology, Estimation of population total and population mean, variance and standard error of the estimates. Allocation of sample size – Equal allocation, proportional allocation, Neyman optimum allocation (without cost function), variance of the estimates in the above cases. Systematic sampling and two stage sampling (Brief outlines without any derivation).

Unit 4:

Unit 5:
Design of experiments: Principle of the design of experiments: Replication, randomisation and local control. Completely Randomised design, Randomised Block Design and Latin square Design with their analysis. Advantages and disadvantages of the above designs. Factorial designs (2^2 and 2^3) illustrations, main effects and interaction effects.

Note: Use of Electronic Calculators is allowed.
PRACTICAL-2

The following topics are prescribed for practical work:

1. Estimation of means and its standard Error in the case of:
   (i) Simple random sampling.
   (ii) Stratified sampling.

2. Allocation of sample size:
   (i) Proportional allocation.
   (ii) Optimum allocation.
   (iii) Equal allocation.

3. Test of Significance:
   (i) Large sample tests for mean and proportions.
   (ii) t-test for (a) $H_0 : \mu = \mu_0$
        (b) $H_0 : \mu_1 = \mu_2$
   (iii) Tests of hypothesis $H_0 : \rho = \rho_0$ and $H_0 : \rho_1 = \rho_2$
         (a) $\chi^2$ – test for testing $H_0 : \sigma = \sigma_0$
         (b) $F$ – test for equality of two variances.
   (iv) $\chi^2$ – tests for goodness of fit and independence of two attributes.

4. Analysis of Variance & Design of Experiment:
   (i) One-way & two-way classifications.
   (ii) Completely Randomised Design.
   (iii) Randomised Block Design.
   (iv) Latin Square Design.

Note:- Use of Electronic Calculators is allowed.
COURSE- V

APPLIED STATISTICS

Unit 1:
Statistical Quality Control: General theory of control charts, causes of variation in quality, control limits, sub-grouping, summary of out-of-control criteria, charts for attributes, np chart, p-chart, c-chart. Chart for variables – \( \bar{X}, R \) and sigma charts.

Unit 2:

Unit 3:

Unit 4:
Index number – its definition, applications of index numbers, price quantity and value relatives, link and chain relatives, problems involved in computation of index numbers, use of averages, simple and weighted aggregative and average methods, Laspeyre’s, Passche’s Marshall Edgeworth and Fisher’s index numbers, time and factor reversal tests of index numbers. Consumer Price Index.

Unit 5:

Note:- Use of Electronic Calculators is allowed.
B.Sc.-II

COURSE- VI

COMPUTATIONAL TECHNIQUES

Unit 1:
Finite Differences: Difference tables, operators $E$ and $\Delta$. Factorial notation.
Interpolation- Newton's formula for equal intervals.

Unit 2:
Divided differences, Newton's divided differences interpolation formula, Lagrange's interpolation formula.

Numerical Integration: Trapezoidal rule, Simpson's $1/3$ rule and $3/8$ rule, Cotes method.

Unit 3:
Introduction to Computer: What is Computer, Characteristics, limitation and applications of computer. Fundamentals of Hardware, Software and their types, number system (Binary Octal, Hexadecimal), Operating System and its types.

Computer Language and Communication: Communication, Components of communication, modes of communication, MODEM, digital and Analog Signals, Introduction to networking, various topologies of network, LAN, WAN, Working Knowledge of Internet. Low level language, High level language, 4GL, Introduction to DBMS, Advantages of DBMS.

Unit 4:
Input and output operation, decision making with IF, IF-ELSE, Nesting IF, ELSE IF ladder, Switch structure, goto structure, loops- FOR, WHILE, DO-WHILE, BREAK, CONTINUE.

Unit 5:
Array Declaration, initialization, of one-Dimensional and two dimensional.
Function, use of function, declaration of function, function calling, call by value, call by reference, recursion, parameter passing and array passing.

Note: Use of Electronic Calculators is allowed.
PRACTICAL-3

The following topics are prescribed for practical work:

1. Control Charts:
   \( \bar{X}, R \), \( p \) and \( c \) - Charts.

   Seasonal Fluctuations / Seasonal Indices.

3. Index Numbers: Construction of various Index numbers and application of mathematical tests.


5. Computer applications: Problems involving sequential, Decision making and looping structure.
   Arrays applications - Searching, Sorting, Largest & smallest element of array, addition, multiplication of 2 arrays, Simple concept of functions, parameter passing).

   Statistical Problems – Mean, variance moments, correlation and regression.

6. Numerical Methods:
   (i) Newton’s methods.
   (ii) Newton’s Gregory formula.
   (iii) Gauss Backward & forward formula, Lagrange’s formula.
   (iv) Trapezoidal Rule, Simpson’s 1/3rd and 3/8th rules.

Note:- Use of Electronic Calculators is allowed.
## M.Sc. STATISTICS (2003-2004 onwards)

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<tr>
<td>II</td>
<td>Probability Theory &amp; Stochastic Processes</td>
<td>3</td>
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<td>III</td>
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<td>IV</td>
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<td>V</td>
<td>Linear Estimation and Designs of Experiments</td>
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<td>VII</td>
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<td>VIII (b)</td>
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<td>VIII (c)</td>
<td>Computer Programming &amp; Applications</td>
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*Note:* Only one of the above courses VIII (a), (b), (c)

| P-3 | Practical-III Based on Courses VII & VIII | 4 | 70 | 6 |
| IX | Operations Research | 3 | 60 | 3 |
| X (a) | Time Series and S.Q.C. | 3 | 60 | 3 |
| X (b) | Economics Statistics & Demography | | | |
| X (c) | Econometric Theory | | | |

*Note:* Only one of the above courses X (a), (b), (c)

| XI (a) | Statistical Inference II | 3 | 60 | 3 |
| XI (b) | Bayesian Inference | | | |
| XI (c) | Actuarial Statistics | | | |

*Note:* Only one of the above courses XI (a), (b), (c)

| XII (a) | Project & Seminar | – | 40+20 | 3 |
| XII (b) | Mathematical Programming | 3 | 60 | 3 |
| XII (c) | Reliability Theory | 3 | 60 | 3 |

*Note:* Only one of the above courses XII (a), (b), (c). A student can opt for XII (a) “Project & Seminar” only if he obtains at least 55% marks in M.Sc. (Prev.)

| P-4 | Practical-IV Based on Courses IX, X & XI | 4 | 70 | 6 |

**Total** 500
Course-I: Mathematical Analysis: Matrices, Difference Equations and Laplace Transforms

Matrices:- Algebra of matrices, definition of rank, elementary transformations and their impact on rank, elementary matrices and their inverse, normal form of a matrix and related important theorems, rank of the product of two matrices.

Vector and Vector space, linearly dependent and independent set of vectors and related theorems, sub-space of an n-vector space, basis of a sub-space.

System of linear homogeneous and non-homogeneous equations, necessary and sufficient conditions for the consistency of a system of non-homogeneous equations.

Characteristics matrix, equations and roots of a matrix, Caley Hamilton theorem, Unitary and Orthogonal matrices, Inner product of vectors and length of a vector, Orthogonal vectors.

Quadratic forms, Congruence of quadratic forms, Canonical form. Definite, semi-definite and indefinite quadratic forms, Orthogonal reduction of a real symmetric matrix. Simultaneous reduction of a pair of quadratic forms.

Difference Equations:- Linear homogenous difference equations with constant/variable coefficients. Solution of non-homogeneous linear difference equations with constant coefficients. Trial method for finding the particular solution of a non-homogeneous linear difference equation with constant coefficient.

Laplace Transform:- Laplace and Laplace – Stieljites transforms with their important properties. Inverse Laplace – transform. Mean and variance in terms of Laplace transform. Solution of simple differential equation and differential difference equations with the help of Laplace – transform.
Course-II: Probability Theory & Stochastic Processes

**Probability:** Bayes' theorem, Random variable, Marginal and Conditional Distributions, Expectation, Tchebycheff's inequality and its improvement, modes of convergence (in probability almost sure, distribution, mean-square), Characteristic functions, Uniqueness and inversion theorems of characteristic functions, Continuity theorem, Weak law of large numbers, Bernoulli theorem, Khintchine's theorem, Strong law of large numbers, Kolmogorov theorem, Central Limit theorem, Linderberg-Levy and Liapounoff's forms, Generating functions.

**Stochastic Process:** Introduction to stochastic processes, Index set, State-space, Discrete and continuous type, Markov process, Markov chains one step and n-step transition probabilities, Chapman-Kolmogorov equations, First passage and first return probabilities, Classification of states, Communicating classes, Periodicity, Stationary probability distributions and limit theorems for ergodic chains, Markov chains with continuous state space.

Books Recommended:

1. **Bhat** : Modern Probability Theory
2. **Parzen, E.** : Modern Probability Theory and Applications
3. **Cramer, H.** : Mathematical Methods of Statistics
4. **Wilks, S.S.** : Mathematical Statistics
Course-III: Sampling Techniques

Basic Principles in sampling, Survey enquiries, choice of sampling units, Problems of sample size, Bias in Selection and Estimation.

Stratified Sampling: Reasons for stratification, choice of strata, choice of sampling unit, stratified random sampling, Estimates of Population mean and its variance, choice of sample sizes in different strata, variances of estimates with different allocations, effects of deviation from optimum allocation, estimation of the gain in precision due to stratification, cost function, construction of strata.

Systematic Sampling: Estimation of sample mean its variance. Comparison of systematic sampling with simple random and stratified sampling.

Ratio and Regression Estimation: Ratio and regression methods of estimation, variances of the estimates, optimum property of ratio estimates, comparison among regression, ratio and simple unbiased estimates.

Cluster Sampling: Estimates of mean and its variance for equal and unequal clusters, Efficiency in terms of intra-class correlation, optimum unit of sampling, sampling with replacement, Estimation of mean and its variance.

Multistage sampling with special reference to two stage design, double sampling.
Non-sampling errors, problems of non-response, errors of measurements, interpenetrating sub-sampling. Randomized response techniques.

**Unequal Probability Sampling:** PPS sampling schemes, sampling techniques with varying probabilities for simple random sampling. Hurwits Thompson estimates. Midzuno Sen Sampling Scheme.

**Books Recommended:**

1. Cochran W.G. : Sampling Technique
3. Raj D. : Sampling Theory

**Course-P-1: Practical I**

Practicals based on Courses I, II & III

The exam. will be of 4 hours duration consisting of

(i) Three practical problems : 45 Marks
(ii) Viva : 13 Marks
(iii) Annual record : 12 Marks

**Total : 70 Marks**
Course-IV: Probability Distributions

Review of Binomial, Poisson and Normal distributions, Joint, marginal and conditional distributions, Truncated and limiting distributions, Beta, Gamma, Bi-variate normal distributions, Sampling distributions of:

- Mean and Variance
- Chi-square, students 't', and F distributions (null case only).
- Order Statistics, Sample range Sample Median and quintiles.
- Second order moments, correlation and regression coefficients (for the case when population correlation coefficient is zero).

Books Recommended:

1. Goon Gupta & Dasgupta
   : Fundamentals of Statistics (Vol. I)
2. Gupta S. & Kapoor V.K.
   : Mathematical Statistics
3. Wilks S.S.
   : Mathematical Statistics
4. Kendall, M.G.
   : Advanced Theory of Statistics (Vol. II)
5. Mood A.M. & Graybill F.A.
   : Introduction of the Theory of Statistics

Course-V: Linear Estimation and Design of Experiments

Linear estimation, Markoff's theorem, Cochran's theorems, random and mixed models. Test of linear hypothesis, Analysis of variance and co-variance.

Principles of design of experiments, Uniformity trials, Completely randomized. Randomized block and Latin square designs including missing plot techniques, Factorial
experiments ($2^2$, $3^2$, $3^3$ systems only), complete and Partial confounding, Split plot and strip plot designs, balanced incomplete block designs, parametric relations and analysis under fixed effect model.

**Books Recommended:**

2. Kempthorne, O. : The Design & Analysis of Experiments
4. Das and Giri : Designs of Experiments

**Course-VI: Statistical Inference-I**


**Interval Estimation:** Determination of confidence intervals based on small and large samples, Relation between confidence estimation and hypothesis testing, Unbiased confidence interval.

**Methods of Estimation:** Method of maximum likelihood, properties of maximum likelihood estimates, Other methods of estimation (moments, minimum $\chi^2$ and modified minimum $\chi^2$).
Testing of Hypothesis-I: Simple and Composite Hypothesis, Pure and Randomized Tests, Errors of the first and second kinds, Level of significance, Power of a test, Most powerful test, Neyman-Pearson Lemma and its generalization, Derivation of Common Tests of a simple hypothesis against a simple alternative, Uniformly most powerful tests. UMP tests of one sided hypothesis for distributions with monotone likelihood ratio tests.

Testing of Hypothesis-II: UMP unbiased tests, similar tests with Neyman structure, Locally best unbiased tests, type A and A1 critical regions for the exponential family. Likelihood ratio tests, Derivation of common likelihood ratio tests. Asymptotic distribution of the logarithm of likelihood ratio.

Books Recommended:

2. Rao, C.R. : Linear Statistical Inference and its Applications
5. Rohrg V.K. : Statistical Inference
8. Lehmann E.L. : Testing of Statistical Hypothesis

Course-P-2: Practical II

Practicals based on Courses IV, V & VI

The exam will be of 4 hours duration consisting of

(i) Three practical problems : 45 Marks
(ii) Viva : 13 Marks
(iii) Annual record : 12 Marks

Total : 70 Marks
Course-VII: Multivariate Analysis


Books Recommended:

2. A.M. Khirsagar : Multivariate Analysis
3. Frutcher : Introduction to Factor Analysis

Course-VIII (a): Advanced Theory of Experimental Designs


Analysis: Analysis of factorial design (2x4, 3x3^2), Square and rectangular Lattice designs, partially balanced incomplete block designs, General analysis of incomplete block designs with recovery of interblock information.

Response Surfaces: Fractional replication in case of $2^n$ and $3^m$ types. Analysis of Group Experiments.
### Books Recommended:

4. Kempthorne, O. : *The Design and Analysis of Experiments (John Wiley and Sons)*
6. D.R. Rao : *Constructions and Combinatorial Problems in Design of Experiments*
7. Das and Giri : *Designs of Experiments*

### Other Books for References:

2. Davis, O.W. : *Design and Analysis of Experiments in Industry*

### Course-VIII (b): Medical Statistics

**Clinical Trials:** Clinical trials, Drug Screening, Standard design, Cross-over designs and order effects, Koch's non-parametric approach to the analysis of data from cross-over trials, Garts and Mc Memars tess, Sample size considerations, Repeated significance tests, open, closed and triangular stopping boundaries.

**Epidemiology:** Mortality and Morbidity rates, incidence rates, prevalence rates, Retrospective (case Control) and prospective (Cohert or longitudinal) studies; Relative risk, Odds ratio, attributable risk, Cornfield and Garts methods, Mantel-Haenszel methods. Reid-Frost and Green-Wood models of Epidemiology Models for carrier borne and host vector diseases, Estimation of latent and infections periods.

Bio-assay: Role of transformations-log, square root and reciprocal transformations; Box-Cox transformation, Probit and logit analysis, Parallel line and slope ratio assay; Fieller's theorem.

Dose-response relationship, Quantal response surfaces; Estimation of median effective dose, Estimation of unknown concentration and potency, Applications of Robbins-Monro process.

Course-VIII (c): Computer Programming and its Applications


Computer Language and Communication: Communication, Components of communication, modes of communication, serial and parallel transmission, Knowledge of Internet, Internet explorer 5.0 Introduction to networking, various topologies of network, LAN, WAN, Low level language, High level language, 4GL, Introduction to data structures-array, linked list, stack, queue, tree Introduction to DBMS, Advantages of DBMS.

Programming C: Design of Algorithms and flow charts, Character set Constants, Variables and Data Types, Declaration of Variables, Operators, and Expressions.

Input and output operation, control flow structures including sequential, selective & repetitive, Array items, initializing, accessing array elements, string functions
Sy: M.Sc.(Final) Statistics

Function, use of function, declaration of function, function calling, call by value, call by reference, recursion, parameter passing and array passing.

Pointer declaration, initialization, Structures declaration, implementation

Programs for:
1. Central Tendencies
2. Measures of Dispersion
3. Correlation and Regression
4. Interpolation and Numerical Integration.

Use of software Packages:
1. MS Excel
2. SPSS

Books Recommended:
1. P.K. Sinha : Fundamental of Computer
2. Yashwant Kanitkar : Let Us C
3. Balaguru Swamy : Ansi C

Course-P-3: Practical III

Practicals based on Courses VII & VIII

The exam will be of 4 hours duration consisting of
(i) Three practical problems : 45 Marks
(ii) Viva : 13 Marks
(iii) Annual record : 12 Marks

Total : 70 Marks
Course-IX: Operations Research

Introduction: Definition and scope of Operations Research, different Types of models, simulation technique and Monte Carlo Methods.

Linear Programming: Mathematical formulation graphical and simplex methods of solution. Application to allocation of resources in industry, Transportation and assignment problems.

Inventory Control: Economic lot size formulae of Harris in the case of known demand and its extension allowing shortages. The case of random demand, Discrete and continuous cases, Newspaper boy problem.

Replacement Problem: Replacement of items that deteriorate with time and that fail suddenly.

Queuing Theory: The case of Poisson input and exponential Erlangian, regular and general service time Queuing formulae and use in determining the optimum service rate and number of channels, Machine Repair problems.

Theory of Games: Game and strategy, two person zero sum game, pure and mixed strategies, Fundamental theorems of rectangular games, resolving finite games.

Project Management: CPM and PERT, probability of project completion.

Books Recommended:

1. Kanti Swarup, Gupta, P.K. & Mannohan
   Operations Research

   Introduction to Operations Research (John Wiley & Sons)
   Chapter 7,8,17
Course-X (a): Time Series and Statistical Quality Control


Quality Control: Concept of quality and meaning of control Different types of control charts like $\bar{X}$, R, p, np, and c, Sampling inspection VS. 100% inspection, single, double, multiple and sequential sampling plans for attribute, OC, AOQ, ASN and ATI curves, concepts of producer's and consumer's risk, AQL and LTPD etc., Variable sampling plans, Total quality management, Process Analysis and Optimization, ISO 9000 Standards.

Books Recommended:

Course-X (b): Economic Statistics and Demography

Distribution of Income and Demand Analysis: Pareto’s Law, General distribution of income, concentration ratios, Lorenz curve, demand function, price and income elasticities of demand and their computation from the market statistics and family budget data, some mathematical relation among elasticities, Engel curves.

Demography: Sources of demographic data, Limitations and uses of demographic data, vital rates and ratios, definition, construction and uses, life tables, complete and abridged construction of life table from vital statistics and census returns, uses of life tables, logistic and other population growth curves, Measure of fertility gross and net reproduction rates, Stationary and stable population theory, Uses of Lotka’s stable population theory in estimation of demographic parameters, methods of inter-censal and post-censal estimation.

Books Recommended:

2. Wold, H. : Demand Analysis (John Wiley and Sons)
3. Cox, P.R. : Demography (Cambridge University Press)
Course-X (c): Econometric Theory

**Linear Regression Model:** Estimation of parameters by least squares and maximum likelihood methods, tests of hypotheses, R² and adjusted R², the problem of prediction, tests for structural change, use of dummy variables, specification error analysis related to explanatory variables, idea of Stein-rule estimators and their properties, Use of extraneous information in the form of exact linear restrictions and stochastic linear restrictions, Restricted regression and mixed regression methods and their properties, tests for restrictions, multicollinearity, its measures and remedies, idea of ridge regression.

**Generalized Linear Regression Model:** Estimation of parameters by generalized least squares method under non-spherical disturbances, heteroskedasticity, estimation procedures and tests for heteroskedastic disturbances, autocorrelation, estimation procedures under autocorrelated disturbances, Durbin Watson test.

**Errors-in-variables Model:** Inconsistency of least squares method, instrumental variables method.

**Seemingly Unrelated Regression Equation Model:** Least squares, generalized least squares and feasible generalized least squares estimators and their asymptotic properties, optimality of least squares methods, Simultaneous Equations model structural and reduced forms, rank and order conditions for the indentifiability, indirect least squares, two stage least squares and limited information maximum likelihood methods of estimation and their asymptotic properties, K-class estimators and choice of characterizing scalar k, idea of three stage least squares and full information maximum likelihood method of estimation.

**Books Recommended:**

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<thead>
<tr>
<th>No.</th>
<th>Author(s)</th>
<th>Title</th>
<th>Publisher/Chapter(s)</th>
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<td>Chapter 6,11</td>
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<td>Theil</td>
<td>Principles of Econometrics</td>
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<td>6.</td>
<td>Malinvaud</td>
<td>Econometrics</td>
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**Course-XI (a): Statistical Inference II**

**Decision Analysis:** Elements of a decision problem. Decision making environments, Pay-off matrix and Opportunity loss (Regret) table for single-stage, decision making, Laplace, Maximin or Minimax, Maximax or Minimin, Savage and Hurwitz criteria of decision under uncertainty.

EMV / EOL criterion for decision under risk. Concept of EVPI.

Decision tree analysis for multistage decision problem.

Need for sequential procedures, SPRT and its properties, Fundamental Identity of Wald, OC and ASN functions, optimality of SPRT (Under usual approximation).


**Non Parametric Inference:** Confidence intervals, test for randomness. Tests based on runs and signs for one sample and two sample problems. Median Test, Wilcoxon test, Mann-Whitney test.
Books Recommended:

1. Ferguson : Mathematical Statistics – A decision theoretic approach
2. Berger : Statistical Decision Theory
3. Lehman : Testing Statistical Hypotheses (2nd Ed.)
4. Lehman : Estimation Theory
6. Rao : Linear Statistical Inference and its Application
8. Wald : Sequential Analysis

Course-XI (b): Bayesian Inference

Subjective interpretation of probability in terms of fair odds, Evaluation of (i) subjective probability of an event using a subjectively unbiased coin (ii) subjective prior distribution of a parameter. Bayes theorem and computation of the posterior distribution.

Natural Conjugate family of priors for a model. Hyper parameters of a prior from conjugate family. Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension. Enlarging the natural conjugate family by (i) enlarging hyper parameter space (ii) mixtures from conjugate family, choosing an appropriate member of conjugate prior family. Non-informative, improper and invariant priors. Jeffrey's invariant prior.

**Bayesian Point Estimation:** As a prediction problem from posterior distribution. Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0 – 1 loss. Generalization to convex loss functions. Evaluation of the estimate in terms of the posterior risk.
Bayesian Interval Estimation: Credible intervals, Highest posterior density regions, interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval.

Bayesian Testing of Hypothesis: Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Prior odds, Posterior odds, Bayes factor for various types of testing hypothesis problems depending upon whether the null hypothesis and the alternative hypothesis are simple or composite. Specification of the Bayes tests in the above cases. Discussion of Lindley’s paradox for testing a point hypothesis for normal mean against the two sided alternative hypothesis.

Bayesian prediction problem.

Large sample approximations for the posterior distribution.

Bayesian calculations for non-conjugate priors: (i) Importance sampling, (ii) Obtaining a large sample of parameter values from the posterior distribution using Acceptance – Rejection methods, Markov Chain Monte Carlo methods and other computer simulation methods.

Books Recommended:


Other Books for References:

Course-XI (c): Actuarial Statistics

**Probability Models and Life Tables:** Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtail future lifetime, force of mortality.

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

Multiple life functions, joint life and last survivor status, insurance and annuity benefit through multiple life functions evaluation for special mortality laws.

Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications.

**Insurance and Annuities**

**Principles of Compound Interest:** Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.
Life Insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, differed insurance and varying benefit insurance, recursions, commutation functions.

Life Annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

Net Premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

Some Practical Considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses.

Claim amount distributions, approximating the individual model, stop-loss insurance.

Books Recommended:


Course-XII (a): Project and Seminars

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<th>Component</th>
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<tr>
<td>Dissertation</td>
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<tr>
<td>Viva-Voce</td>
<td>10</td>
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<tr>
<td>Two Seminars</td>
<td>20</td>
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A student has to submit a project report in the form of dissertation on the topic allotted to him/her by the concerned supervisor. This project and its Viva-Voce would be evaluated at the time of M.Sc. Final Examination by the supervisor and an examiner nominated by the university from the panel of examiners recommended by the Board of Studies in Statistics.

Seminar will be evaluated internally by the respective supervisors of the projects.

Course-XII (b): Mathematical Programming

Convexity: Convex sets and their properties, Extreme points and basic feasible solution, convex and concave functions (including quasi and pseudo convexity) and their properties, Quadratic forms and their extrema.

Linear Programming: Mathematical formulation, Theory of simplex method, Artificial variables technique, Degeneracy and its resolution. Dual linear program and duality theorems.

Non-linear Programming: Kuhn Tucker optimality conditions, Quadratic Programming, Wolf's and Beale's algorithms for solving quadratic programming problems.


Books Recommended:

Course-XII (c): Reliability Theory

Reliability Theory: Reliability concepts and measures, components and systems, coherent systems, reliability of coherent systems, cuts and paths, modular decomposition, bounds on system reliability, structural and reliability importance of components, maintainability and availability, Life distributions, Failure rates and bath tub failure rate curve, exponential, weibull, Gamma and log normal models, Linearly increasing hazard model, mean time to system failure and mean time between failures, component and system reliability, series, parallel and k-out of n configuration, Active and standby redundancy, Feasibility for repair and preventive maintenance, time to system failure and steady state availability for some simple Markovian and Non-Markovian models.

Bayesian Estimation: Bayes estimation, Exponential, Weibull and normal distribution, Reliability estimation.

Basic ideas of accelerated life testing.

Books Recommended:

4. Balaguru Swami C. : Reliability Engineering
5. Govil A.K. : Reliability Engineering
Course-P-4: Practical IV

Practicals based on Courses IX, X & XI

The exam. will be of 4 hours duration consisting of:

(i) Three practical problems : 45 Marks

(ii) Viva : 13 Marks

(iii) Annual record : 12 Marks

Total : 70 Marks