SHIVAJI UNIVERSITY, KOLHAPUR.

B
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(2009)

Revised Syllabus For

Bachelor of Science (Part III) Statistics

Syllabus to be implemented from June 2012 onwards

Shivaji University, Kolhapur

B. Sc. III Statistics
Structure of the course
To be implemented from June 2012

Theory

Semester V

Paper. No.	Title of the paper	Internal Marks	External Marks	Total Marks
IX	Probability Distributions - I	10	40	50
X	Statistical Inference - I	10	40	50
XI	Designs of Experiments	10	40	50
XII	Programming in C	10	40	50

Semester VI

Paper. No.	Title of the paper	Internal Marks	External Marks	Total Marks
XIII	Probability Distributions - II	10	40	50
XIV	Statistical Inference - II	10	40	50
XV	Sampling Theory	10	40	50
XVI	Operations Research	10	40	50

Practical

Paper No.	Title of the Practical	Marks for Practical	Journal	Oral	Total Marks
IV	Probability Distributions & R- Software	36	5	4	45
V	Statistical Inference	36	5	4	45
VI	Designs of Experiments & Sampling Methods	36	5	4	45
VII	Programming in C & Operations Research	36	5	4	45
	A Project Report & Viva -voce	20	-	-	20

1. Nature of Project

(i) Identification of problem where statistical techniques can be used.

(ii) Planning and execution of data collection.

(iii) The Marking system for the project work is as follows:

- Data Collection: 5 Marks
- Analysis of Data: 5 Marks
- Conclusion: 5 Marks
- Viva on Project: 5 marks

(iv) Project in B.Sc. III will be conducted in a group of 5 to 6 students.

2. Internal Marks : There shall be 10 marks for internal mid semester test for each theory paper. Test will be based on 10 multiple choice questions each of one mark.

3. Nature of Question papers (Theory)

COMMON NATURE OF QUESTION FOR THEORY PAPER MENTIONED SPERATELY:

4. Nature of practical papers :

(i) Each Practical Question paper must contain **Four** questions.

(ii) Each question should contain TWO bits from different units.

(iii) Student should attempt **Any Two** questions.

(iv) Each question should carry **18** marks and to be distributed according to following points :

(a) Aim of the Experiment .... 2 Marks

(b) Statistical formulae ..... 4 Marks

(c) Observation Tables ..... 4 Marks

(d) Calculations ..... 5 Marks

(e) Conclusion / result of the experiment .....3 Marks.

5. Instructions

(i) While attempting questions based on R-software and C-Programming, students have to write the program in C and the commands of R-software on their Answer-book. Then after getting an approval of examiner, he/she should type the same and run the program. Final result should be shown to the examiner online or the printout may be attached.

(ii) Duration of each practical paper should be of four hours.

5. Requirements :

(i) There should be two subject experts at the time of practical examination.

(ii) Laboratory should be well equipped with 20 scientific calculators, 20 computers, 2 printers with sufficient backup facility (UPS/ Inverter /Generator).

EQUIVALENCE FOR THEORY PAPERS

(From June 2012)

Old Syllabus		Revised Syllabus	
Paper No.	**Title of the Paper**	**Paper No.**	**Title of the Paper**
V	Probability Distributions	Sem.V / P. IX	Probability Distributions - I
		Sem. VI/ P.XIII	Probability Distributions - II
VI	Statistical Inference	Sem. V / P X	Statistical Inference - I
		Sem. VI / P XIV	Statistical Inference - II
VII	Design of Experiments and Sampling Methods	Sem. V / P XI	Design of Experiments
		Sem. VI / P XV	Sampling Theory
VIII	Programming in C and Operations Research	Sem. V / P XII	Programming in C
		Sem. VI / P XVI	Operations Research

EQUIVALENCE FOR PRACTICAL PAPERS

(From June 2012)

Old Syllabus		Revised Syllabus	
Paper No.	**Title of the Practical Paper**	**Paper No.**	**Title of the Practical Paper**
IV	Probability Distributions and R software	IV	Probability Distributions and R software
V	Statistical Inference	V	Statistical Inference
VI	Design of Experiments and Sampling Methods	VI	Design of Experiments and Sampling Methods
VII	Programming in C and Operations Research	VII	Programming in C and Operations Research

B. Sc. III Statistics
Semester V
Paper IX
Probability Distributions - I

Unit-1: Univariate Continuous Probability Distributions

1.1 Laplace (Double Exponential) Distribution (15)

i. p. d. f., DE (μ , λ).
ii. Nature of the probability curve.
iii Distribution function, quartiles.
iv m. g. f., mean, variance, moments, β_1, β_2, γ_1 and γ_2.
v Laplace distribution as the distribution of the difference of two i. i. d. exponential variates with mean θ.
vi Examples and problems.

1.2 Lognormal Distribution

i. p. d. f. , LN(μ, σ^2)
ii. Nature of the probability curve.
iii. Moments, mean, variance, median, mode, β_1, γ_1 coefficients.
iv. Relation with N(μ, σ^2).
v. Examples and problems.

1.3 Cauchy Distribution

i. p. d. f., C(μ, λ).
ii. Nature of the probability curve.
iii. Distribution function, quartiles, non-existence of moments.
iv. Additive property for two independent Cauchy variates (statement only), statement of distribution of the sample mean.
v. Relationship with uniform and Students't' distribution.
vi Distribution of X/Y where X and Y are i. i. d. N(0, 1).
vii. Examples and problems.

1.4: Weibull Distribution

i. p. d. f. , W(α, β)
ii. Distribution function, quartiles, mean and variance, coefficient of variation, relation with gamma and exponential distribution.
iii. Examples and problems.

Unit -2. Bivariate Normal Distribution (10)

i. p. d. f. of a bivariate normal distribution, BN (μ_1, μ_2, σ_1^2, σ_2^2, ρ)

Marginal and conditional distributions, identification of parameters, conditional expectation and conditional variance, regression of Y on X and of X on Y., independence and uncorrelated-ness imply each other, m. g. f and moments. Distribution of aX + bY + c, where a, b and c are real numbers.

ii. Cauchy distribution as the distribution of Z = X/Y where

(X, Y) ~ BN(0, 0, σ_1^2, σ_2^2, ρ)

iii. Examples and problems.

Unit-3: Truncated Distributions (10)

i. Truncated distribution as conditional distribution, truncation to the right, left and on both sides.

ii. Binomial distribution B(n, p) left truncated at X = 0 (value zero not observable), its p.m.f, mean, variance.

iii. Poisson distribution P(m), left truncated at X = 0 (value zero not observable), its p.m.f., mean and variance.

iv. Normal distribution $N(\mu, \sigma^2)$ truncated
   (i) to the left below a
   (ii) to the right above b
   (iii) to the left below a and to the right above b, its p.d.f. and mean.

v. Exponential distribution with parameter θ left truncated below a, its p.d.f., mean and variance.

vi. Examples and problems.

Unit-4: Order Statistics (10)

i. Order statistics for a random sample of size n from a continuous distribution, definition, derivation of distribution function and density function of the i-th order statistic , particular cases for i=1 and i=n.

ii. Derivation of joint p. d. f. of i -th and j- th order statistics , statement of distribution of the sample range.

iii. Distribution of the sample median when n is odd.

iv. Examples and Problems.

Books Recommended

1. Cramer H.: Mathematical Methods of Statistics, Asia Publishing House, Mumbai.
2. Mood, A. M., Graybill K, Bose. D. C. : Introduction to Theory of Statistics. (Third edition) Mc-Graw Hiil Series.
3. Lindgren B. W.: Statistical Theory (Third Edition), Collier Macmillan International Edition, Macmillan Publishing Co. Inc. New York. 4. Hogg, R. V. and Craig A. T. : Introduction to Mathematical Statistics (Third Edition), Macmillan Publishing Company, Inc. 866, 34d Avenue, New York, 10022.
5. Sanjay Arora and Bansi Lal : New Mathematical Statistics (First Edition), Satya Prakashan, 16/17698, New Market, New Delhi, 5 (1989).
6. Gupta S. C and Kapoor V. K. : Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 88, Daryaganj, New Delhi 2.
7. Rohatgi V. K.: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
8. Feller. W. : An Introduction of Probability Theory and its Applications. Vol. , Wiley Eastern Ltd.. Mumbai.
9. Jhonson and Kotz: Continuous Univariate Distributions I and II
   : Discrete Distributions
   : Multivariate Distributions
10. Bhat B. R.: Modern Probability Theory. New Age International.

B. Sc. III Statistics
Semester V
Paper X
Statistical Inference - I

Unit - 1: Point Estimation (15)

i. Notion of a parameter, parameter space, general problem of estimation, estimating an unknown parameter by point and interval estimation.

ii. Point estimation: Definition of an estimator (statistic) & its S.E., distinction between estimator and estimate, illustrative examples.

iii, Properties of estimator: Unbiased estimator, biased estimator, positive and negative bias, examples of unbiased and biased estimators. Proofs of the following results regarding the unbiased estimators:

(a) Two distinct unbiased estimators of $\varphi(\theta)$ give rise to infinitely many unbiased estimators of $\varphi(\theta)$

(b) If T is unbiased estimator of θ then φ (T) is an unbiased estimator of φ (θ) provided φ (.) is a linear function.

Sample variance is a biased estimator of the population variance. Illustration of unbiased estimator for the parameter and parametric function.

iv. Relative efficiency of T_1 with respect to T_2, where T_1 and T_2 are unbiased estimators. Use of mean square error to modify the above definition for biased estimator. Minimum Variance Unbiased Estimator (MVUE) and Uniformly Minimum Variance Unbiased Estimator (UMVUE), uniqueness of UMVUE whenever it exists. Illustrative examples.

v. Consistency : Definition, proof of the following :

(i) Sufficient condition for consistency,

(ii) If T is consistent for θ and φ (.) is a continuous function then φ (T) is consistent for φ (θ)

Illustrative examples.

Unit - 2: Likelihood and Sufficiency (12)

i. Definition of likelihood function as a function of the parameter θ for a random sample from discrete and continuous distributions. Illustrative examples.

ii. Sufficiency: Concept of sufficiency, definition of sufficient statistic through (i) conditional distribution (ii) Neyman factorization criterion. Pitman Koopman form and sufficient statistic. Proof of the following properties of sufficient statistic:

(i) If T is sufficient for θ then φ (T) is also sufficient for provided θ provided φ (.) is a one-to-one and on- to function.

(ii) If T is sufficient for θ then T is sufficient for φ (θ).

Fisher information function: Definition, amount of information contained in a statistic. Statement regarding equality of the information in $(x_1, x_2, \ldots, x_n)$ and in a sufficient statistic T, concept of minimal sufficient statistic. With illustrations to exponential family.

(iii) Illustrative examples.

Unit - 3: Cramer Rao Inequality **(7)**

Statement and proof of Cramer Rao inequality. Definition of Minimum Variance Bound Unbiased Estimator (MVBUE) of $\varphi(\theta)$. Proof of the following results:

(i) If MVBUE exists for θ then MVBUE exists for $\varphi(\theta)$, if $\varphi(.)$ is a linear function.

(ii) If T is MVBUE for θ then T is sufficient for θ. Examples and problems.

Unit - 4: Methods of Estimation **(11)**

i. Method of maximum likelihood, derivation of maximum likelihood estimators for parameters of standard distributions. Use of iterative procedure to derive MLE of location parameter μ of Cauchy distribution, invariance property of MLE, relation between MLE and sufficient statistic. Illustrative examples.

ii. Method of moments: Derivation of moment estimators for standard distributions. Illustrations of situations where MLE and moment estimators are distinct and their comparison using mean square error. Illustrative examples.

iii. Method of minimum chi-square: Definition, derivation of minimum chi-square estimator for the parameter. Illustrative examples.

Books Recommended

1. Kale, B. K.: A first Course on Parametric Inference
2. Rohatgi, V. K.: Statistical Inference
3. Rohatgi, V. K.: An introduction to Probability Theory and Mathematical Statistics
4. Saxena H. C. and Surenderan : Statistical Inference
5. Kendall M. G. and Stuart A.: An advanced Theory of Statistics
6. Lindgren, B. W.: Statistical Theory
7. Lehmann, E. L.: Theory of Point Estimation
8. Rao, C. R.: Linear Statistical Inference
9. Dudewicz C. J. and Mishra S. N. : Modern Mathematical Statistics
10. Fergusson, T. S.: Mathematical statistics.
11. Zacks, S.: Theory of Statistical Inference.
12. Cramer, H.: Mathematical Methods of Statistics.
13. Cassela G. and Berger R. L.: Statistical Inference

B.Sc. III (Statistics)

Semester V

Paper XI

Designs of Experiments

Unit – 1: Simple Designs of Experiments I : (10)

1.1 Basic Concepts:

i. Basic terms in design of experiments: Experimental unit, treatment, layout of an experiment.

ii. Basic principles of design of experiments: Replication, randomization and local control.

iii Choice of size and shape of a plot for uniformity trials, the empirical formula for the variance per unit area of plots.

1.2 Completely Randomized Design (CRD)

i. Application of the principles of design of experiments in CRD, layout, model, assumptions and interpretations:

ii. Estimation of parameters, expected values of mean sum of squares, components of variance.

ijj. Breakup of total sum of squares in to components.

iv Technique of one way analysis of variance (ANOVA) and its applications to CRD.

v. Testing for equality for treatment effects and its interpretation. F-test for testing H_0, test for equality of two specified treatment effects.

Unit- 2: Simple Design of Experiments II : (15)

2.1 Randomized Block Design(RBD):

i. Application of the principles of design of experiments in RBD, layout, model , assumptions and interpretations:

ii. Estimation of parameters, expected values of mean sum of squares, components of variance.

iii. Breakup of total sum of squares into components.

iv Technique of two way analysis of variance (ANOVA) and its applications to RBD.

v. Tests and their interpretations , test for equality of two specified treatment effects, comparison of treatment effects using critical difference (C.D.).

vi. Idea of missing plot technique.

vii. Situations where missing plot technique is applicable.

viii Analysis of RBD with single missing observation.

2.2 Latin Square Design (LSD)

i Application of the principles of design of experiments in LSD, layout, model, assumptions and interpretations:

ii Breakup of total sum squares into components.

iii Estimation of parameters, expected values of mean sum of squares, components of variance. preparation of analysis of variance (ANOVA) table.

iv Tests and their interpretations, test for equality of two specified treatment effects, comparison of treatment effects using critical difference (C.D.).

v Analysis of LSD with single missing observation.

vi Identification of real life situations where CRD, RBD AND LSD are used:

Unit – 3 Efficiency of design and ANOCOVA (10)

3.1 Efficiency of design

i Concept and definition of efficiency of a design.

ii Efficiency of RBD over CRD.

iii Efficiency of LSD over CRD and LSD over RBD.

3.2 Analysis of Covariance (ANOCOVA) with one concomitant variable

i Purpose of analysis of covariance.

ii Practical situations where analysis of covariance is applicable.

iii Model for analysis of covariance in CRD and RBD. Estimation of parameters (derivations are not expected).

iv Preparation of analysis of covariance (ANOCOVA) table, test for $\beta = 0$, test for equality of treatment effects (computational technique only).

Note :- For given data, irrespective of the outcome of the test of regression coefficient (β), ANOCOVA should be carried out.

Unit – 4 : Factorial Experiments (10)

i General description of factorial experiments, 2^2 and 2^3 factorial experiments arranged in RBD.

ii Definitions of main effects and interaction effects in 2^2 and 2^3 factorial experiments.

iii Model , assumptions and its interpretation.

iv Preparation of ANOVA table by Yate's procedure, test for main effects and interaction effects.

v General idea and purpose of confounding in factorial experiments.

vi Total confounding (Confounding only one interaction) : ANOVA table, testing main effects and interaction effects.

vii Partial Confounding (Confounding only one interaction per replicate): ANOVA table, testing main effects and interaction effects.

viii Construction of layout in total confounding and partial confounding in 2^3 factorial experiment.

Books Recommended

1. Federer, W.T. : Experimental Design, Oxford and IBH publishing Company, New Delhi.

2. Cochran, W.G. and Cox, G.M. : Experimental Design, John Wiley and Sons, Inc., New York.

3. Montgomery, D.C.: Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.

4. Das, M.N. and Giri, N.C. : Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.
5. Goulden, G.H. : Methods of Statistical Analysis, Asia Publishing House, Mumbai.
6. Kempthrone, O. : Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.
7. Snedecor, G.W. and Cochran, W.G. : Statistical Methods, Affiliated East-West Press, New Delhi.
8. Goon, Gupta, Dasgupta : Fundamental of Statistics, Vol. I and II, The World Press Pvt. Ltd. Kolkata.
9. Gupta, S.C. and Kapoor, V.K. : Fundamentals of Applied Statistics, S. Chand & Sons, New Delhi.
10. C.F. Jeff Wu, Michael Hamada : Experiments, Planning Analysis and Parameter Design Optimization.

B.Sc. III (Statistics)
Semester V
Paper XII
Programming in C

Unit-1: Introduction (10)

i History of C, importance of C, general language structure, character set, key words, identifiers, constants, types of constants, variables, data type(character, integer, floating point, long int, double, exponential) , declaration of variables, assignment statement, assigning values to variables.

ii Operators and expressions: Arithmetic operators, relational operators, relational expression, logical operators, increment operator, decrement operator, arithmetic expressions,, library functions: cos(x), sin(x), tan(x), exp(x), abs(x), floor(x), mod(x, y), log(x), log10(x), pow(x, y), sqrt(x), random( ), randomize( ).

iii Input and output operators: getchar( ), putchar( ), scanf( ), printf( ), Conversion specification -%c %d, %f, %s, %e, %u. Escape sequences : \n, \t.

Unit-2: Decision Making (10)

i Control statement: if, if ... else statement, switch statement, simple illustrative examples.

ii Loop control statements: Concept and use of looping, while, do ...while, for, compound assignment operators, break, continue, exit, goto, nested loops, programs using control statements.

Unit-3: Arrays and User Defined Functions (14)

3.1 Arrays

Concept of arrays, one-dimensional array, declaration of one-dimensional array, initialization of one-dimensional array. Two-dimensional array, declaration of two-dimensional array, initialization of two dimensional array. Programs using arrays.

3.2 User defined function

Definition of function, use of function, declaration, passing values between functions, local and global variables, scope of function, Passing array elements to a function, calling function by value, by reference, recursion,.

Unit-4 : Strings, Pointers and Files (11)

4.1 Strings

String of characters input/output functions for using gets(), puts(). Use of standard string library functions strlen, strwr, strupr, strrev, strchr, strcmp, strcpy and strcat. Programs using string.

4.2 : Pointers

Introduction to pointers, Pointer notation, passing pointers as parameters of function arrays and pointers. Simple programs.

4.3 :FILES

Operating a file in different modes as read, write, append, closing a file, writing data into a file. Reading data from a file and appending file, Simple programs.

Book Recommended

1. Karnighan, B. W. and Ritchie,. D.: The C Programming Language, Prentice-Hall.
2. Rajaraman : Computer Programming in C, Prentice Hall (Eastern Economy Edition).
3. Kanetkar, Y. : Let us C, BFB Publishers, New Delhi.
4. Gottfried : Programming with C (Schaum Outline Series), McGraw Hill Co. London.
5 Balguruswami E: Programming in ANSI 'C'.
6 Mullish Cooper : Spirit of 'C'.

B. Sc. III Statistics
Semester VI
Paper XIII
Probability Distributions - II

Unit-1: Convergence and Limit Theorem

1.1 Chebychev's Inequality

i. Chebycheve's inequality for discrete and continuous distributions.

ii. Examples and problems on standard distributions (Binomial, Normal, Exponential etc.)

1.2 Convergence

i. Definition of convergence of sequence of random variables (i) in probability, (ii) in distribution, (iii) in quadratic mean.

ii. If $X_n \xrightarrow{P} X$ then $g(X_n) \xrightarrow{P} g(X)$ where g is continuous function without proof.

iii. Examples and problems.

1.3 Weak Law of Large Numbers and Central Limit Theorem

i. Weak law of large numbers (WLLN) statement and proof for i. i. d. random variables with finite variance.

ii. Central limit theorem: Statement and proof for i. i. d. random variables with finite variance, proof based on m. g. f..

iii. Simple examples based on Bernoulli, binomial, Poisson and chi-square distribution.

Unit-2: Finite Markov Chains (11)

2.1 Basic concepts:

definition and examples of stochastic process, classification of general stochastic process into discrete – continuous time, discrete – continuous state space, type of stochastic process, problems and examples.

2.2 Markov chain:

definition and examples of Markov chain, stochastic matrix, transition probability matrix, Chapman - Kolmogorov equation (statement only), n step transition probability matrix, classification of states, simple problems. Stationary probability distribution, applications.

2.3 Continuous Markov chain:

Pure birth process, Poisson process, birth and death process. (Derivations not expected),

2.4 Examples and problems.

Unit-3: QUEUING THEORY (9)

i. Introduction, essential features of queuing system, input source, queue configuration, queue discipline, service mechanism.

ii. Operating characteristics of queuing system, transient- state and steady state, queue length, general relationship among system characteristics.

iii. Probability distribution in queuing system: Distribution of arrival, distribution of inter arrival time, distribution of departure and distribution of service time (Derivations are not expected).

iv. Types of queuing models:
v. Solution of queuing Model: M/M/1, using FCFS queue discipline.
vi Problems and examples.

Unit-4: Reliability Theory (10)

i. Binary Systems: Block diagrams, definition of binary coherent structure and illustrations. Coherent system of component at most three, (a) Series, (b) Parallel, (c) 2 out of 3: G Minimal cut, minimal path representation of system.
iii. Reliability of binary System: reliability of above systems h(p), when components are independent and identically distributed with common probability p of operating.
iii. Ageing Properties: definitions: Hazard rate, hazard function, survival function, concept of distributions with increasing and decreasing failure rate (IFR, DFR). Relationship between survival function and hazard function, density function and hazard rate, derivations results (1) Hazard rate of a series system of components having independent life times is summation of component hazard rates.(2) Life time of series system of independent components with independent IFR life times is IFR,
iv. Examples on exponential and Weibull distributions.

Books Recommended

1. Cramer H.: Mathematical Methods of Statistics, Asia Publishing House, Mumbai.
3. Lindgren B. W.: Statistical Theory (Third Edition), Collier Macmillan International Edition, Macmillan Publishing Co. Inc. New York. .. . .
4. Hogg, R. V. and Craig A. T. : Introduction to Mathematical Statistics (Third Edition), Macmillan Publishing Company, Inc. 866, 34d Avenue, New York, 10022.
5. Sanjay Arora and Bansi Lal : New Mathematical Statistics (First Edition), Satya Prakashan, 16/17698, New Market, New Delhi, 5 (1989).
6. Gupta S. C and Kapoor V. K. : Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 88, Daryaganj, New Delhi 2.
7. Rohatgi V. K.: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
8. Medhi J : Stochastic Processes. Wiley Eastern Ltd. New Delhi.
9. Hoel, Port and Stone: Introduction to Stochastic Processes, Houghton Mifflin.
10. Feller. W. : An Introduction of Probability Theory and its Applications. Vol. , Wiley Eastern Ltd.. Mumbai.
12. Bhat B. R.: Probability Theory and its Applications
13. Karlin and Taylor: Stochastic Process.
14. Ross S: Probability Theory.
15. Bhat B. R.: Stochastic Models : Analysis and Applications. New Age International.
16. Zacks S. : Introduction to Reliability Analysis, Probability Models and Statistical Methods, Springer Verlag.
17. Taha H. A.: Operation research – An Introduction, Fifth edition, Prentice Hall of India, New Delhi

18. Barlow R. E. and Proschan Frank : Statistical Theory of Reliability and Life Testing. Holt Rinebart and Winston Inc., New Yark.
19. Sinha S. K. : Reliability and Life Testing, Second Edition, Wiley Eastern Publishers, New Delhi.
20. Trivedi R. S. : Probability and Statistics with Reliability and Computer Science Application, Prentice – Hall of India Pvt. Ltd., New Delhi.
21. Parimal Mukhopadhyaya : An Introduction to the Theory of Probability. World Scientific Publishing.

B. Sc. III Statistics
Semester VI
Paper XIV
Statistical Inference - II

Unit - 1: Interval Estimation (11)

i. Notion of interval estimation, definition of confidence interval, length of confidence interval, confidence bounds. Definition of Pivotal quantity and its us in obtaining confidence intervals and bounds.

ii. Interval estimation for the following cases:
   (i) Mean μ of normal distribution (σ^2 known and σ^2 unknown).
   (ii) Variance σ^2 of normal distribution (μ known and μ unknown).
   (iii) Difference between two means $\mu_1 - \mu_2$,
      (a) for a sample from bivariate normal population,
      (b) for samples from two independent normal populations.
   (iv) Ratio of variances for samples from two independent normal populations.
   (v) Mean of exponenential distribution.
   (vi) Population proportion and difference of two population proportions of two independent large samples.
   (vii) Population median using order statistics.
   Illustrative examples.

Unit - 2: Parametric Tests (15)

i. Statistical hypothesis, problems of testing of hypothesis, definitions and illustrations of (i) simple hypothesis (ii) composite hypothesis, critical region, type I and type II error, probabilities of type I & type II errors. Power of a test, observed level of significance, p-value, size of a test, level of significance, problem of controlling probabilities of type I & type II errors.

ii Definition of Most Powerful (MP) test. Statement and proof (sufficient part) of Neyman - Pearson (NP) lemma for simple null hypothesis against simple alternative hypothesis for construction of MP test. Examples of construction of MP test of level α.

iii Power function of a test, power curve, definition of uniformly most powerful (UMP) level α test. Use of NP lemma for constructing UMP level α test for one-sided alternative. Illustrative examples.

iv Likelihood Ratio Test: Procedure of likelihood ratio test, statement of its properties
   (i) Likelihood Ratio test involving mean and variance of normal population.
   (ii) Likelihood Ratio test involving difference between two population means and ratio of two population variances of normal population.

Unit - 3: Sequential Tests (7)

General theory of sequential analysis and its comparison with fixed sample procedure. Wald's SPRT of strength (α, β), for simple null hypothesis against simple alternative hypothesis. Illustrations for standard distributions like

binomial, Poisson, exponential and normal. Graphical and tabular procedure for carrying out the test. Illustrative examples.

Unit - 4: Non- parametric Test (12)

Notion of non-parametric statistical inference (test) and its comparison with parametric statistical inference. Concept of distribution free statistic. Test procedure of:

(ii) Run test for one sample (i.e. test for randomness) and run test for two independent sample problems.
(iii) Sign test for one sample and two sample paired observations
(iv) Wilcoxon's signed rank test for one sample and two sample paired observations.
(v) Mann-Whitney U - test (two independent samples)
(vi) Median test (two large independent samples)
(vii) Kolmogorov Smirnov test for one and for two independent samples.

Books Recommended

1. Kale, B. K.: A first Course on Parametric Inference
2. Rohatgi, V. K.: Statistical Inference
3. Rohatgi, V. K.: An introduction to Probability Theory and Mathematical Statistics
4. Saxena H. C. and Surenderan : Statistical Inference
5. Kendall M. G. and Stuart A.: An advanced Theory of Statistics
6. Lindgren, B. W.: Statistical Theory
7. Cassela G. and Berger R. L.: Statistical Inference
8. Lehmann, E. L: Testing of Statistical Hypothesis
9. Rao, C. R.: Linear Statistical Inference
10. Dudewicz C. J. and Mishra S. N. : Modern Mathematical Statistics
11. Fergusson, T. S.: Mathematical statistics.
12. Zacks, S.: Theory of Statistical Inference.
13. Cramer, H.: Mathematical Methods of Statistics.
14. Gibbons, J. D.: Non-parametric Statistical Inference.
15. Doniel: Applied Non-parametric Statistics
16. Siegel, S.: Non-parametric Methods for the behavioral sciences.
17. Kunte, S. ; Purophit, S. G. and Wanjale, S.K.: Lecture notes on Non-parametric Tests.

B.Sc. III (Statistics)

Semester VI

Paper XV

Sampling Theory

Unit – 1 Basic Terminology and Simple Random Sampling (10)

1.1 Basic Terminology

i Concept of distinguishable elementary units, sampling units, sampling frame, random sampling and non-random sampling. Advantages of sampling method over census method.

ii Objectives of a sample survey

iii Designing a questionnaire, Characteristics of a good questionnaire.

iv Planning, Execution and analysis of sample survey

1.2 Simple random sampling

i Simple random sampling from finite population of size N with replacement (SRSWR) and without replacement (SRSWOR): Definitions, population mean and population total as parameters, inclusion probabilities.

ii Sample mean $\bar{y}$ as an estimator of population mean, derivation of its expectation, standard error and estimator of standard error.

iii $N\bar{y}$ as an estimator of population total, derivation of its expectation, standard error and estimator of standard error.

iv Sampling for dichotomous attributes.Estimation of population proportion Sample proportion (p) as an estimator of population proportion (P), derivation of its expectation, standard error and estimator of standard error using SRSWOR..Np as an estimator of total number of units in the population possessing the attribute of interest, derivation of its expectation, standard error and estimator of standard error.

1.3 Determination of the sample size.

Determination of the sample size (n) for the given:

(i) margin of error and confidence coefficient,

(ii) coefficient of variation of the estimator and confidence coefficient.

Unit – 2 Stratified Sampling : (15)

i Real life situations where stratification can be used.

ii Description of stratified sampling method where sample is drawn from individual stratum using SRSWOR method.

iii (a) $\bar{y}_{st}$ as an estimator of population mean $\bar{Y}$, derivation of its expectation, standard error and estimator of standard error.

(b) $N\bar{y}_{st}$ as an estimator of population total, derivation of its expectation, standard error and estimator of standard error.

iv Problem of allocation: Proportional allocation, Neyman's allocation and optimum allocation, derivation of the expressions for the standard errors of the above estimators when these allocations are used.

v Gain in precision due to stratification, comparison amongst SRSWOR, stratification with proportional allocation and stratification with optimum allocation.

vi Cost and variance analysis in stratified random sampling, minimization of variance for fixed cost, minimization of cost for fixed variance, optimum allocation as a particular case of optimization in cost and variance analysis.

Unit-3 Other Sampling Methods (11)

3.1 Systematic Sampling

i Real life situations where systematic sampling is appropriate. Technique of drawing a sample using systematic sampling.

ii Estimation of population mean and population total, standard error of these estimators.

iii Comparison of systematic sampling with SRSWOR.

iv Comparison of systematic sampling with SRSWOR and stratified sampling in the presence of linear trend.

v Idea of Circular Systematic Sampling.

3.2 Cluster Sampling

i Real life situations where cluster sampling is appropriate. Technique of drawing a sample using cluster sampling.

ii Estimation of population mean and population total (with equal size

clusters), standard error of these estimators

iii Systematic sampling as a particular case of cluster sampling.

3.3 Two Stage and Multi Stage Sampling

Idea of two-stage and multistage sampling.

Unit – 4: Sampling Methods using Auxiliary variables and Non Sampling Errors (9)

4.1 Ratio Method

i Concept of auxiliary variable and its use in estimation

ii Situations where Ratio method is appropriate.

iii Ratio estimators of the population mean and population total and their standard errors (without derivations), estimators of these standard errors.

iv Relative efficiency of ratio estimators with that of SRSWOR

4.2 Regression Method

i Situations where Regression method is appropriate.

ii Regression estimators of the population mean and population total and their standard errors (without derivations), estimators of these standard errors.

iii Comments regarding bias in estimation

iv Relative efficiency of regression estimators with that of

a) SRSWOR b) Ratio estimator.

4.3 Sampling and non-sampling errors.

Concept of sampling and non-sampling errors. Handling of non-response cases.

Books Recommended

1. Cochran, W.G: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
2. Sukhatme, P.V. and Sukhatme, B.V. : Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.
3. Des Raj : Sampling Theory.
4. Daroga Singh and Choudhary F.S.; Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd., New Delhi.
5. Murthy, M.N: Sampling Methods, Indian Statistical Institute, Kolkata.
6. Mukhopadhay, Parimal: Theory and Methods of Survey Sampling, Prentice Hall.

B.Sc. III (Statistics)
Semester VI
Paper XVI
Operations Research

Unit-1: Linear programming (15)

1.1 Basic concepts

Statement of the Linear Programming Problem (LPP), formulation of problem as. L.P. problem. Definition of (i) a slack variable, (ii) a surplus variable. L.P. problem in (i) canonical form, (ii) standard form. Definition of (i) a solution, (ii) a feasible solution, (iii) basic variable and non basic variable, (iv) a basic feasible solution, (v) a degenerate and a non-generate solution, (vi) an optimal solution.

1.2 Solution of L.P.P.

(i) Graphical Method: Solution space, obtaining an optimal solution, unique and non-unique optimal solutions.

(ii) Simplex Method:

(a) Initial basic feasible solution (IBFS) is readily available: obtaining an IBFS, criteria for deciding whether obtained solution is optimal, criteria for unbounded solution, , more than one optimal solutions.

(b) IBFS not readily available: introduction of artificial variable, Big-M method, modified objective function, modifications and applications of simplex method to L.P.P., criterion for no solution.

1.3 Duality Theory:

Writing dual of a primal problem, solution of L.P.P. with artificial variable.

1.4 Examples and problems.

Unit-2: Transportation and Assignment Problems (15)

2.1 Transportation problem

i Transportation problem (T. P.), statement of T. P., balanced and unbalance T. P.

ii Methods of obtaining initial basic feasible solution of T.P. (i) North West corner rule (ii) Method of matrix minima (least cost method), (iii) Vogel's approximation(VAM).

iii MODI method of obtaining Optimal solution of T. P, uniqueness and non-uniqueness of optimal solutions, degenerate solution.

iv Examples and problems.

2.2 Assignment Problem:

i Statement of an assignment problem, balanced and unbalanced assignment problem, relation with T.P, optimal solution of an assignment problem using Hungarian method.

ii Examples and problems.

2.3 Sequencing Problem :

i. Introduction. Statement of problem.

ii. Procedure of processing n jobs on two machines.

iii. Procedure of processing n jobs on three machines and m machines. Computations of elapsed time and idle times.

Unit-3: Critical Path Method (CPM) and Project Evaluation Review Technique (PERT) (7)

3.1 Definitions:

(i) event, (ii) node, (iii) activity, (iv) critical activity, (v) project duration,

3.2 CPM :

Construction of a network, definitions of (i) earliest event time, (ii) latest event time, (iii) Critical path, float, total float, free float, independent float and their significance. Determination of critical path.

3.3 PERT :

Construction of network, pessimistic time, optimistic time, most likely time. Determination of critical path, determination of mean, variance and standard deviation of project duration, computations of probability of completing the project in a specified duration.

3.4 Examples and problems.

Unit-4: Decision Theory (8)

i Introduction, steps in decision theory approach.

ii Type of decision making environments.

iii Decision making under uncertainty: Criteria of optimism, criteria of pessimism, equally likely decision criterion, criterion of regret.

iv Decision making under risk: Expected monetary value, expected opportunity loss, expected value of perfect information.

v Examples and problems.

Book Recommended

1. Gass E.: Linear Programming Method and Applications, Narosa Publishing House, New Delhi.
2. Shrinath L. S.: Linear Programming.
3. Taha H. A.: Operation research – An Introduction, Fifth Edition, Prentice Hall of India, New Delhi.
4. Saceini, Yaspan, Friedman : Operations Research Method and Problems, Wiley International Edition.
5. Shrinath, L. S. : Linear Programming, Affiliated East-West Press Pvt. Ltd., New Delhi.
6. Phillips, D. T., Ravindra, A., Solberg, J.: Operations Research Principles and Practice, John Wiley and Sons Inc.
7. Sharma, J. K. : Mathematical Models in Operations Research, Tau McGraw Hill Publishing Company Ltd., New Delhi.
8. Kapoor, V. K. ; Operations Research, Sultan Chand and Sons, New Delhi.
9. Gupta, P. K. and Hira, D. S. : Operations Research, S. Chand and Company Ltd., New Delhi.
10. Shrinath, L. S. : PERT-CPM Principles and Applications, Affiliated East-West Press Pvt. Ltd., New Delhi.

B.Sc. III (Statistics)
Practical IV
Probability Distributions and R - Software

1. Model sampling from Laplace and Cauchy distributions.
2. Model sampling from log normal and Weibull distributions.
3. Fitting of log normal distribution.
4. Fitting of truncated binomial distribution.
5. Fitting of truncated poison distribution.
6. Model sampling from truncated binomial and poison distributions.
7. Model sampling from truncated normal and exponential distributions.
8. Model sampling from bivariate normal distribution.
9. Application of bivariate normal distribution.
10. Data input/output
    - Creation of vector using commands
      c , rep , seq , scan
    - Creation of data frame using commands
      data frame , edit
    - Arithmetic operation on vectors
11. Diagrammatic representation of data
    Simple bar diagram, subdivided bar diagram, pie diagram.
12. Graphical representation of data
    Histogram, frequency polygon, Ogive curves
13. Computation of probabilities of type I and type II errors and power of a test
14. Construction of LR test.
15. Analysis of Completely Randomized Design (CRD).
16. Analysis of Randomized Block Design (RBD).
17. Fitting of Binomial and Poisson distributions.
18. Fitting of Normal distribution

Reference Books:

1. Purohit Sudha : Lecture notes on R.
2. Verzani : Using R for introductory Statistics.

Practical –V
Statistical Inference

1. Point estimation by method of moments for discrete distributions.
2. Point estimation by method of moment for continuous distributions.
3. Point estimation by method of maximum likelihood (one parameter).
4. Point estimation by method of maximum likelihood (two parameters).
5. Point estimation by method of minimum chi-square.
6. Interval estimation of location and scale parameters of normal distribution (single sample).
7. Interval estimation of difference of location and ratio of scale parameters of normal distribution (two samples).
8. Interval estimation for population proportion and difference between two population proportions.
9. Interval estimation for population median using order statistics.

10. Construction of MP test.
11. Construction of UMP test.
12. Construction of SPRT for binomial, Poisson distributions, also using graphical procedure.
13. Construction of SPRT for exponential and normal distribution, also using graphical procedure.
14. NP test- -Run test (for one and two independent samples).
15. NP test –Sign test and Wilcoxon's signed rank test (for one and two samples paired observation).
16 NP test-- Mann-whitney U- test (for two independent samples).
17. NP teat –Median test (for two large independent samples)
18. NP test—Kolmogorov - smirnov test (for one and two independent samples).

PRACTICAL PAPER – VI

Design of Experiments and Sampling Methods

1. Analysis of CRD and RBD.
2. Analysis of Latin Square Design (LSD).
3. Missing Plot Technique for RBD and LSD with one missing observation.
4. Efficiency of i) RBD over CRD and ii) LSD over CRD and RBD.
5. Analysis of Covariance in CRD.
6. Analysis of Covariance in RBD.
7. Analysis of 2^2 and 2^3 Factorial Experiment.
8. Total Confounding.
9. Partial Confounding.
10. Simple Random Sampling for Variables.
11. Simple Random Sampling for Attributes.
12. Determination of Sample Size in SRS for Variables and Attributes.
13. Stratified Random Sampling – I
14. Stratified Random Sampling – II
15. Ratio Method of Estimation.
16. Regression Method of Estimation.
17. Systematic Sampling.
18. Cluster Sampling.

PRACTICAL PAPER VII
Programming in C and Operations Research

1. Use of fundamental functions in C (input /output & type conversion)
2. Use of if and if ... else statement.
3. Use of while loop and do ... while loop.
4. Use of switch statement and for statement.
5. Use of array-I (one dimensional and two dimensional)
6. Function and recursion.
7. Manipulating string character.
8. Fitting of binomial and Poisson distribution
9. Fitting of continuous uniform and exponential distribution.
10. L.P.P. by simplex method I (Slack variable)
11. L.P.P. by simplex method I (Big M method)
12. Transformation problem-I.
13. Transformation problem-II. (Degeneracy)
14. Assignment problem.
15. Sequencing Problem.
16. CPM
17. PERT.
18. Decision Theory.