SOLAPUR UNIVERSITY, SOLAPUR.

Semester Pattern Syllabus

B.Sc. Part-III (Sem.V&VI)

STATISTICS

w.e.f. June 2015

SOLAPUR UNIVERSITY, SOLAPUR
Revised Semester Pattern Syllabus
B.Sc. Part- III
STATISTICS
(w.e.f. June 2015)

SEMESTER V

a) Theory

Sr.No.	Title of the paper	Paper No.	Total Marks
1	Statistical Inference-I	IX	50
2	Sampling Techniques	X	50
3	Probability Distributions & Stochastic Process	XI	50
4	Operations Research and Applied Statistics	XII	50
	Total	**----**	**200**

SEMESTER VI

a) Theory

Sr.No.	Title of the paper	Paper No.	Total Marks
1	Statistical Inference-II	XIII	50
2	Designs of experiment	XIV	50
3	Limit theorems, Reliability and Queuing theory	XV	50
4	C – Programming	XVI	50
	Total	**----**	**200**

b) Practical (Annual)

Sr.No.	Title of the Practical paper	Paper No.	Total Marks
1	Statistical Inference	IV	45
2	Designs of experiment and Sampling Methods	V	45
3	Probability Distributions & R software	VI	45
4	Programming in C, Operations Research and Applied Statistics	VII	45
5	A Project Report and Viva	----	20
	Total	**----**	**200**

SCHEME OF TEACHING:

Sr.No.	Paper	Teaching Scheme (Hrs/Week)			
		L	**T**	**P**	**Total**
1	IX and XIII	3	---	5	8
2	X and XIV	3	---	5	8
3	XI and XV	3	---	5	8
4	XII and XVI	3	---	5	8
	Total	**12**	**---**	**20**	**32**

Note (1) Teaching periods for each theory papers in each semester are Three per week.

(2) Teaching periods for practical paper-IV to paper-VII are Five periods per paper per week per batch of 12 students.

Duration of University Examinations:

1) For each theory paper ,duration is of two hours.
2) For practical paper-IV to paper-VII, four hours for a batch of 12 students annually.

SOLAPUR UNIVERSITY, SOLAPUR

Semester Pattern Syllabus
B.Sc.Part-III
STATISTICS
(w.e.f. June 2015)

Objectives :

The main objective of this course is to develop the advanced statistical skills to the students, which covers concepts of statistical inference, designs of experiment, sampling techniques, distribution theory, operation research, SQC, ‘c’ programming and ‘R’ software. Also the students are expected to conduct a project work which includes data collection and analysis of data using various statistical tools. By the end of course students are expected to

i) Distinguish between point estimation and interval estimation

ii) Understand and solve testing of hypothesis problems

iii) Workout the design of experiment

iv) Utilize various sampling techniques

v) Know various probability distributions ,concept of truncation and their applications to real life situations

vi) Understand the concept of stochastic process , queuing theory and reliability theory

vii) Concept Operation Research, single and double sampling plan

viii) Use of “R” software for various problems

ix) Learn thoroughly ‘C’ programming

x) Know the utility of operations research

xi) Conduct project work to understand how to collect data, analyze it and interpret the results by enhancing his statistical thinking.

SYLLABUS

B.Sc. PART – III : Semester V (Statistics)

Paper IX

STATISTICAL INFERENCE – I

Unit – 1: Point Estimation **(15)**

i) Notion of 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 for θ then $\varphi(T)$ is an unbiased estimator of $\varphi(\theta)$ provided $\varphi(.)$ 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 $\varphi(.)$ is a continuous function then $\varphi(T)$ is consistent for $\varphi(\theta)$.

Illustrative examples.

Unit – 2 : Likelihood and Sufficiency **(15)**

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 :

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

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

Illustrative examples.

iii) Fisher information function : Definition, amount of information contained in a statistic, statement regarding equality of information in ($X_1, X_2, \ldots, X_n$) and in a sufficient statistic T, concept of minimal sufficient statistic, with illustration to exponential family.

Unit – 3 : Cramer Rao inequality **(5)**

Statement and proof of Cramer Rao inequality. Definition of minimum Variance Bound Unbiased Estimator (MVBUE) of φ(θ). Proof of the following results :

a) If MVBUE exists for θ then MVBUE exists for φ(θ), if φ(.) is a linear function.

b) If T is MVBUE for θ then T is sufficient for θ.

Examples and problems.

Unit – 4 : Methods of estimation **(10)**

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.

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. Kendal M.G. and Stuart A. : An advanced Theory of Statistics
6. Siegel, S. : Non-parametric Methods for the Behavioral Sciences.
7. Lindgren, B.W. : Statistical Theory
8. Lehmann, E.L. : Theory of Point Estimation
9. Lehmann, E.L. : Testing of Statistical Hypothesis
10. Rao, C.R. : Linear Statistical Inference
11. Dudewicz C.J. and Mishra S.N. : Modern Mathematical Statistics
12. Fergusson, T.S. : Mathematical Statistics
13. Zacks, S. : Theory of Statistical Inference
14. Cramer, H. : Mathematical Methods of Statistics

B.Sc. PART – III : Semester V (Statistics)
Paper X
SAMPLING TECHNIQUES

Unit – 1 Basic Terminology and Simple Random Sampling (12)

1.1 Basic Terminology

i) Concept of distinguishable elementary units, sampling units, sampling frame, random sampling and non-random sampling.

ii) Objectives of a sample survey.

iii) Designing a questionnaire, characteristics of a good questionnaire.

iv) Planning, execution and analysis of sample survey.

v) Concept of sampling and non-sampling errors.

1.2 Simple Random Sampling for attributes

i) sampling for dichotomous attributes. Estimation of population proportion : sample proportion (p) as an estimator of population proportion (P). derivation of its expectations, standard error and estimator of standard error using SRSWOR.

ii) Np as an estimator of total number of units in the population possessing the attribute of interest, derivation of its expectations, standard error and estimator of standard error.

1.3 Determination of the sample size.

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

a) margin of error and confidence coefficient,

b) coefficient of variation of the estimator and confidence coefficient.

Unit – 2 Stratified Random Sampling : (13)

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) $\overline{y_{st}}$ as an estimator of population mean $\overline{Y}$, derivation of its expectations, standard error and estimator of standard error.

iv) $N\overline{y_{st}}$ as an estimator of population total, derivation of its expectations, standard error and estimator of standard error.

v) 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.

vi) Gain in precision due to stratification, comparison amongst SRSWOR, stratification with proportional allocation and stratification with Optimum allocation.

vii) 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 (10)

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 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 multi-stage sampling.

Unit – 4 Sampling Methods using Auxiliary variables (10)

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 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 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.

Books Recommended

1. Gupta, S.C. and Kapoor, V.K. : Fundamentals of Applied Statistics, S. Chand and Sons, New-Delhi
2. Cochran, W.G. : Sampling Techniques, Wiley Eastern Ltd., New-Delhi.
3. Sukhatme, P.V. and Sukhatme, B.V. : Sampling Theory of Surveys with Applications, Indian Society Agricultural Statistics, New Delhi.
4. Des Raj : Sampling Theory.
5. Daroga Singh and Choudhari F.S. : Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd., New-Delhi.
6. Murthy, M.N. : Sampling Methods, Indian Statistical Institute, Kolkata.
7. Mukhopadhay, Parimal : Theory and Methods of Survey Sampling, Prentic Hall.

B.Sc. PART – III : Semester V (Statistics)

Paper XI

PROBABILITY DISTRIBUTIONS AND STOCHASTIC PROCESS

Unit – 1 : Univariate Continuous Probability Distributions **(15)**

1.1 Laplace (Double Exponential) Distribution

i) p.d.f.

$$f(x) = \frac{\lambda}{2}\exp[-\lambda\,|\,x-\mu\,|\,] \quad ; \quad -\infty < x < \infty \;,\; -\infty < \mu < \infty \;,\; \lambda > 0$$
$$= 0 \quad ; \quad \text{elsewhere}$$

Notation : $X \sim Lap(\mu, \lambda)$

ii) Nature of probability curve.

iii) Distribution function, quartiles.

iv) m.g.f., mean, variance

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 : Cauchy Distribution.

i) p.d.f.

$$f(x) = \frac{\lambda}{\pi\left\{\lambda^2 + (x-\mu)^2\right\}} \quad ; -\infty < x < \infty \;,\; -\infty < \mu < \infty \;,\; \lambda > 0$$
$$= 0 \quad ; \quad \text{elsewhere}$$

Notation : $X \sim C(\mu, \lambda)$.

ii) Nature of 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 $\frac{X}{Y}$ where X and Y are i.i.d. N(0,1).

vii) Examples and problems.

1.3 Lognormal Distribution.

i) p.d.f.

$$f(x) = \frac{1}{x}\frac{1}{\sigma\sqrt{2\pi}}\exp\left\{\frac{-1}{2\sigma^2}\left[\log_e x-\mu\right]^2\right\} \quad ; \quad 0 < x < \infty, -\infty < \mu < \infty, \sigma > 0$$

= 0 ; elsewhere.

Notation : X ~ LN(μ, σ^2)

ii) Nature of probability curve.

iii) Moments, mean, variance, median, mode, β_1 , γ_1 coefficients.

iv) Relation with N(μ, σ^2) .

v) Examples and problems.

Unit – 2 : Bivariate Normal Distribution. (10)

i) p.d.f. of a bivariate normal distribution.

$$f(x,y) = \frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}}\exp\left\{\frac{-1}{2(1-\rho^2)}\left[\left(\frac{x-\mu_1}{\sigma_1}\right)^2+\left(\frac{y-\mu_2}{\sigma_2}\right)^2-2\rho\left(\frac{x-\mu_1}{\sigma_1}\right)\left(\frac{y-\mu_2}{\sigma_2}\right)\right]\right\}$$

for $-\infty < x , y < \infty$, $-\infty < \mu_1, \mu_2 < \infty$, $\sigma_1 > 0$, $\sigma_2 > 0$, $-1 < \rho < 1$

= 0 ; elsewhere.

Notation : (X,Y) ~ BN($\mu_1, \mu_2, \sigma_1^2, \sigma_2^2, \rho$)

Marginal and conditional distributions, identification of parameters, conditional expectation, conditional variance, regression of Y on X and X on Y, independence and uncorrelated-ness imply each other, m.g.f. and moments.

ii) If (X,Y) ~ BN($0, 0, \sigma_1^2, \sigma_2^2, \rho$) then to find the joint distribution of U = $\frac{X}{Y}$ and V = Y, and to identify that the distribution of U is Cauchy.

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 , its p.m.f., mean and variance.

iii) Poisson distribution P(m) , left truncated at X = 0 , its p.m.f., mean and variance.

iv) Normal distribution N(μ, σ^2) truncated

a) to the left below a,
b) to the right above b,
c) 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) Real life situations.

Unit – 4 : Finite Markov Chains (10)

4.1 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.

4.2 Markov chain :

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

4.3 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 Hill 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 Co. Inc. New York.
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, S. Chand and Sons, New-Delhi
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 Stochastic Processes, Houghton Mifflin.
10. Feller, W. : An Introduction of Probability Theory and its Applications. Vol. I, Wiely Eastern Ltd. Mumbai.

B.Sc. PART – III : Semester V (Statistics)
Paper XII
OPERATIONS RESEARCH AND APPLIED STATISTICS

Unit – 1 Linear Programming (11)

1.1 Basic Concepts

Statement of the linear programming problem (LPP), formulation of the problem as LPP. Definition of a) slack variable, b) surplus variable. LPP in a) canonical form, b) standard form. Definition of a) a solution, b) a feasible solution, c) basic variable and non-basic variable, d) a basic feasible solution, e) a degenerate and non- degenerate solution,

f) an optimal solution.

1.2 Solution of LPP.

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

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, no 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 LPP.

iii) Examples and problems.

Unit – 2 : Transportation and Assignment Problems (11)

2.1 Transportation Problem

i) Transportation Problem (TP), statement of TP, balanced and unbalanced TP.

ii) Methods of obtaining IBFS of TP. by a) North-West Corner Rule b) Method of Matrix Minima (Lowest Cost Method), c) Vogel's approximation method (VAM).

iii) Modification method of obtaining Optimal solution of TP, 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 TP, optimal solution of an assignment problem using Hungarian method.

ii) Examples and problems.

Unit – 3 Critical Path Method (CPM) and Project Evaluation Review Technique (PERT) (11)

3.1 Definitions :

a) event b) node c) activity d) critical activity e) project duration.

3.2 CPM :

Construction of network, definitions of a) earliest event time, b) latest event time, c) 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 : Acceptance Sampling for Attributes : (12)

4.1 Introduction, concept of sampling inspection plan, comparison between hundred percent inspections and sampling inspection. Procedures of acceptance sampling with rectification : single sampling plan and double sampling plan.

4.2 Explanation of the terms – a) producer's risk, consumer's risk, Acceptance Quality Level (AQL), Lot Tolerance Fraction Defective (LTFD), Average Outgoing Quality (AOQ), Average Outgoing Quality Limit (AOQL), Average Sample Number (ASN), Average Total Inspection (ATI), Operating Characteristic (O.C.) curve, AOQ curve.

4.3 Single Sampling Plan :

Evaluation of probability of acceptance using a) Hypergeometric b) Binomial c) Poisson distributions. Derivation of AOQ and ATI. Graphical determination of AOQL.

4.4 Double Sampling Plan :

Evaluation of probability of acceptance using Poisson approximation, derivation of ASN and ATI (with complete inspection of second sample), derivation of the approximation formula of AOQ.

Books Recommended

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

B.Sc. PART – III : Semester VI (Statistics)

Paper – XIII

STATISTICAL INFERENCE-II

Unit – 1 : Interval Estimation **(10)**

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

ii) Interval estimation for the following cases :

a) Mean μ of normal distribution (σ^2 known and σ^2 unknown).

b) Variance σ^2 of normal distribution (μ known and μ unknown).

c) Difference between two means ($\mu_1 - \mu_2$), for samples from bivariate normal population

d) Difference between two means ($\mu_1 - \mu_2$), for samples from two independent normal populations.

e) Ratio of variances for samples from two independent normal populations.

f) Mean of exponential distribution.

g) Population proportion and difference of two population proportions of two independent large samples.

h) Population median using order statistics.

Illustrative examples.

Unit – 2 : Parametric Tests **(15)**

i) Statistical hypothesis, problems of testing of hypothesis, definition and illustrations of

a) simple hypothesis, b) composite hypothesis, critical region, type I and type II error, probabilities of type I and type II errors, power of a test, p-value, size of a test, level of significance, problem of controlling probabilities of type I and 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 : Definition and Procedure of likelihood ratio test (LRT), Properties of LRT (Statement only).

a) Derivations of LRT involving mean and variance of normal population,

b) Derivations of LRT involving difference between two population means and ratio of two population variances of normal populations.

c)

Unit – 3 : Sequential Tests (08)

General theory of sequential analysis and its comparison with fixed sample procedure. Wald's Sequential Probability Ratio Test (SPRT) of strength (α, β), for simple null hypothesis against simple alternative hypothesis. Illustration for standard distributions like binomial, Poisson, exponential and normal. Graphical and tabular procedure for carrying out the test. Illustrative examples.

Unit – 4 : Non – Parametric Tests (12)

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

i) Run test for one sample (i.e. test for randomness) and run test for two independent samples.

ii) Sign test for one sample and two sample paired observations

iii) Wilcoxon's signed rank test for one sample and two sample paired observations.

iv) Mann-Whitney U test (two independent samples)

v) Median test (two independent samples)

vi) Kolmogrov-Smirnov test for one sample 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. Kendal M.G. and Stuart A. : An advanced Theory of Statistics
6. Siegel, S. : Non-parametric Methods for the Behavioral Sciences.
7. Lindgren, B.W. : Statistical Theory
8. Lehmann, E.L. : Theory of Point Estimation
9. Lehmann, E.L. : Testing of Statistical Hypothesis
10. Rao, C.R. : Linear Statistical Inference
11. Dudewicz C.J. and Mishra S.N. : Modern Mathematical Statistics
12. Fergusson, T.S. : Mathematical Statistics
13. Zacks, S. : Theory of Statistical Inference
14. Cramer, H. : Mathematical Methods of Statistics
15. Gibbons, J.D. : Non-parametric Statistical Inference
16. Doniel : Applied Non-parametric Statistics
17. Cassela G. and Berger R.L. : Statistical Inference
18. Kunte, S. ; Purohit, S.G. and Wanjale, S.K. : Lecture Notes on Non-parametric Tests.

B.Sc. PART – III : Semester VI (Statistics)
Paper XIV
DESIGN OF EXPERIMENTS

Unit – 1 :Simple Design of Experiments I : (12)

1.1 Basic Concepts:

Basic terms in design of experiments: Experimental unit, treatment, layout of an experiment. Idea of critical difference (C.D).

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

Choice of size and shape of a plot for uniformity trials.

1.3 Completely Randomized Design (CRD)

i) Application of the principles of design of experiments in CRD, layout, model:

$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$, $i = 1, 2, \ldots, v$; $j = 1, 2, \ldots, n_i$

Assumptions and interpretations .

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

iii) 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 of treatment effects, hypothesis : $H_0 : \alpha_1 = \alpha_2 = \ldots = \alpha_v = 0$ and its interpretation. F- test for testing H_0 , test for equality of two specified treatment effects.

Unit – 2 : Simple Design of Experiments II : (12)

2.1 Randomized Block Design (RBD) :

i) Application of the principles of design of experiments in RBD, layout, model:

$Y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$, $i = 1, 2, \ldots, v$; $j = 1, 2, \ldots, b$

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) Hypotheses :

$$H_{01} : \alpha_1 = \alpha_2 = \ldots = \alpha_v = 0$$

$$H_{02} : \beta_1 = \beta_2 = \ldots = \beta_b = 0$$

and their interpretations. F- test for testing H_{01} and H_{02} , 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 one & two missing observations.

2.2 Latin Square Design (LSD)

i) Application of the principles of design of experiments in LSD, layout, model:

$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \varepsilon_{ijk}$, i, j, k = 1, 2, . . . ,m ;

Assumptions and interpretations .

ii) Breakup of total sum of 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)Hypotheses : $H_{01} : \alpha_1 = \alpha_2 = . . . = \alpha_m = 0$

$H_{02} : \beta_1 = \beta_2 = . . . = \beta_m = 0$

$H_{03} : \gamma_1 = \gamma_2 = . . . = \gamma_m = 0$

and their interpretations. F- test for testing H_{01}, H_{02} and H_{03} , test for equality of two specified treatment effects, comparison of treatment effects using critical difference (C.D.) .

v) Analysis of LSD with one & two missing observations.

vi)Identification of real life situations where CRD, RBD, and LSD are used.

Unit – 3 Efficiency of Design and split plot design (10)

3.1 Efficiency of Design

i) Concept and definition of efficiency of design.

ii) Efficiency of RBD over CRD.

iii) Efficiency of LSD over CRD and LSD over RBD.

3.2 Split plot design

i) General description of split plot design

ii) Layout and model

iii) Analysis of variance table for testing of significance of main effects and interaction effects

Unit – 4 : Factorial Experiments **(11)**

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

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

iii) Model :

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \ , i = 0, 1 \ , j = 0, 1 \ , k = 1, 2, - - - , r$$

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 experiments.

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 : Fundamentals 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 and Sons, New-Delhi
10. C.F.Jeff Wu, Michael Hamada : Experiments, Planning Analysis and Parameter Design Optimization.
11. Angela dean Daniel Voss : Design and Analysis of Experiments.

B.Sc. PART – III : Semester VI (Statistics)

Paper XV

LIMIT THEOREMS, RELIABILITY AND QUEUING THEORY

Unit – 1 : 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 i^{th} order statistic $X_{(i)}$, particular cases for i = 1 and i = n. Derivation of joint p.d.f. of ($X_{(i)}$, $X_{(j)}$), statement of distribution function of the sample range $X_{(n)}$- $X_{(1)}$.

ii) Distribution of sample median when n is odd.

iii) Examples and problems based on Uniform and Exponential distributions.

Unit – 2 : Convergence and Limit Theorem **(15)**

2.1 Chebychev's Inequality:

i) Chebychev's inequality for continuous distribution in the forms

a) $P(|X-\mu| \geq c) \leq \frac{\sigma^2}{c^2}$ for $c > \sigma$

b) $P(|X-\mu| \geq c\sigma) \leq \frac{1}{c^2}$ for $c > 1$

where $\mu = E(X)$, $\sigma^2 = Var(X) < \infty$

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

2.2 Convergence :

i) Definition of convergence of a sequence of random variables in

a) probability b) distribution c) quadratic mean.

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

iii) Examples and problems.

2.3 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 (CLT) : 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 χ^2 distribution.

Unit – 3 : Queuing Theory **(10)**

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

ii) Operating characteristics of queuing system, transient state, 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.

iv) Types of queuing models , solutions of queuing model M/M/1, using FCFS queue discipline.

v) Problems and examples.

Unit – 4: Reliability Theory **(10)**

i) Definition of a structure function of a system of n components, structure functions of the following systems of at most three components a) Series b) Parallel c) 2 out of 3 .

ii) 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. ‘

iv) 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 of the results

a) Hazard rate of a series system of components having independent life times is summation of component hazard rates.

b) Life time of series system of independent components with independent IFR life times is IFR. Examples on exponential .

Books Recommended

1. Rohatgi, V.K. : An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd. New Delhi.

2. Medhi, J. : Stochastic Processes, Wiley Eastern Ltd. New Delhi.
3. Hoel, Port and Stone : Introduction Stochastic Processes, Houghton Mifflin.
4. Feller, W. : An Introduction of Probability Theory and its Applications. Vol. I, Wiely Eastern Ltd. Mumbai.
5. Jonhson and Kotz : a) Continuous Univariate Distributions I and II. b) Discrete Distributions c) Multivariate Distributions.
6. Bhat, B.R. : Probability Theory and its Applications.
7. Karlin and Taylor : Stochastic Process.
8. Ross, S. : Probability Theory.
9. Bhat, B.R. : Stochastic Model.
10. Zacks, S. : Introduction to Reliability Analysis, Probability Models and Statistical Methods, Springer Verlag.
11. Taha, H.A. : Operation research – An Introduction, Fifth Edition, Prentice Hall of India, New Delhi.
12. Barlow, R.E. and Proschan Frank : Statistical Theory of Reliability and Life Testing, Holt Rinebart and Winston Inc., New York.
13. Sinha S.K. : Reliability and Life Testing, Second Edition, Wiley Eastern Ltd. New Delhi.
14. Trivedi R.S. : Probability and Statistics with Reliability and Computer Science Application, Prentice – Hall of India Pvt. Ltd., New Delhi.

B.Sc. PART – III : Semester VI (Statistics)

Paper XVI

C - PROGRAMMING

Unit – 1 : Introduction **(12)**

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 integer, double, exponential), declaration of variables, assignment statement, assigning values to variables.

ii) Operators and Expressions: Arithmetic operators, relational operators, relational expressions, 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 specifications – %c, %d, %ld, %f, %lf, %s, %e, %u etc. Escape sequences: \n, \t etc.

Unit – 2 Decision Making **(10)**

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

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

Unit – 3 : User Defined Functions and Arrays **(13)**

3.1 User Defined Functions

Definition of function, use of function, declaration, passing values between functions, scope rule of function, recursion, calling function by reference and by value, local and global variables.

3.2 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, passing array elements to a function, programs using arrays.

Unit – 4 : Strings and Pointers **(10)**

4.1 Strings

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

4.2 Pointers

Introduction to pointers, pointer notation, passing pointers as parameters of function, arrays and pointers, simple programs.

Books Recommended

1. Karnighan, B.W. and Ritchi, M. : The C programming language, Prentic-Hall.
2. Rajaraman : Computer Programming in C, Prentic-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. Gass E. : Linear Programming Method and Applications, Narosa Publishing House, New
6. Balguruswami E. : Programming in ANSI ‘C’.
7. Mullish Cooper : Spirit of ‘C’.

B.Sc. PART – III (Statistics)
PRACTICAL - IV
STATISTICAL INFERENCE

1. Point estimation by Method of Moments-I (for discrete distributions).
2. Point estimation by Method of Moments-II (for continuous distributions).
3. Point estimation by Method of Maximum Likelihood-I (for discrete distributions).
4. Point estimation by method of Maximum Likelihood-II (for continuous distributions).
5. Interval estimation of location and scale parameters of normal distribution (single sample).
6. Interval estimation of difference of location and ratio of scale parameters of normal distribution (two samples).
7. Interval estimation for population proportion and difference between two population proportions.
8. Interval estimation for population median using order statistics.
9. Computation of probabilities of Type I and Type II errors and power of a test.
10. Construction of MP Test.
11. Construction of UMP Test.
12. Construction of LR Test.
13. Construction of SPRT for binomial and Poisson distributions.
    (Tabular and graphical Procedures).
14. Construction of SPRT for exponential and normal distribution.
    (Tabular and graphical Procedures).
15. Run Test (for one and two independent samples).
16. Sign Test (for one and two sample paired observations).
17. Wilcoxon's Signed- rank Test (for one and two samples paired observations).
18. Mann-Whitney U Test (for two independent samples).
19. Median Test (for two independent samples).
20. Kolmogrov-Smirnov Test (for one and two independent samples).

B.Sc. PART – III (Statistics)
PRACTICAL V
DESIGN OF EXPERIMENTS AND SAMPLING TECHNIQUES

1. Simple Random Sampling for Attributes.
2. Determination of Sample Size in SRS for Variables and Attributes.
3. Stratified Random Sampling – I.
4. Stratified Random Sampling – II.
5. Ratio Method of Estimation.
6. Regression Method of Estimation.
7. Systematic Sampling.
8. Cluster Sampling.
9 Analysis of Completely randomized design (CRD).
10. Analysis of Randomized Block Design (RBD).
11. Analysis of Latin Square Design (LSD).
12. Missing Plot Technique for RBD with one and two missing observations.
13 Missing Plot Technique for LSD with one and two missing observations.
14. Efficiency of RBD over CRD.
15. Efficiency of LSD over CRD and RBD.
16. Analysis of Split plot Design
17. Analysis of 2^2 factorial Experiment.
18. Analysis of 2^3 factorial Experiment.
19. Total Confounding.
20. Partial Confounding.

B.Sc. PART – III (Statistics)
PRACTICAL VI
PROBABILITY DISTRIBUTIONS AND R- SOFTWARE

1. Model Sampling from Laplace and Cauchy Distribution.
2. Model Sampling from Lognormal Distribution.
3. Fitting of Lognormal Distribution.
4. Fitting of Truncated Binomial Distribution.
5. Fitting of truncated Poisson Distribution.
6. Model Sampling from Truncated Binomial and Poisson Distributions.
7. Model Sampling from Truncated Normal and Exponential Distributions.
8. Model Sampling from Bivariate Normal Distribution.
9. Applications 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 operations 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. Measures of Central Tendency (Grouped / Ungrouped)
14. Measures of Skew ness.
15. Moments and Measures of Kurtosis.
16. Fitting of Binomial Distribution.
17. Fitting of Poisson Distribution.
18. Fitting of Normal Distribution.
19. Regression and Correlation – Linear Regression.
20. Multiple Regression and Correlation.

Reference Books :

1. Purohit Sudha : Lecture Notes on R.
2. Verzani : Using R for Introductory Statistics.

B.Sc. PART – III (Statistics)

PRACTICAL VII

PROGRAMMING IN 'C' AND OPERATIONS RESEARCH AND APPLIED STATISTICS

1. LPP by Simplex Method I (Slack Variable).
2. LPP by Simplex Method II (Big-M Method).
3. Transportation Problem.
4. Assignment Problem.
5. CPM – I
6. CPM – II
7. PERT.
8. Single Sampling Plan
9. Double Sampling Plan
10. Use of input/output function.
11. Evaluating Arithmetic Expressions.
12. Type Conversion in Assignment Statements.
13. Use of if and if - - - else statements.
14. Use of while loop ,do-while loop and for loop.
15. Use of switch statement.
16. Use of Array (one and two dimensional)
17. Functions and Recursion.
18. Manipulating String Characters.
19. Mean and Variance of Grouped and Ungrouped Data.
20. Fitting of Binomial and Poisson Distributions.

Note:

i) Computer printouts are to be attached to the journal.
ii) Student must complete the entire practical to the satisfaction of the teacher concerned.
iii) Student must produce the laboratory journal along with the completion certificate duly signed by Head of Department at the time of practical examination.

Laboratory requirements:

Laboratory should be well equipped with sufficient number of electronic calculators and computers along with necessary software, printers and UPS.

Solapur University, Solapur

Nature of Theory Question Paper (B.Sc.-III)

- **Faculty of Science**

(w.e.f. June 2015)

Time :- 2 hrs. **Total Marks-50**

Q. No.1) **Multiple choice questions.** **(10)**

1) ---

a) b) c) d)

2)
3)
4)
5)
6)
7)
8)
9)
10)

Q.No.2) **Answer any Five of the following** **(10)**

i)
ii)
iii)
iv)
v)
vi)

Q.No.3) **A) Answer any Two of the following** **(06)**

i)
ii)
iii)

B) Write the Answer/Solve/Problem/Note **(04)**

Q.No.4) **Answer any Two of the following** **(10)**

i)
ii)
iii)

Q.No.5) **Answer any One of the following** **(10)**

i)
ii)

Nature of Practical question paper of B.Sc.Part-III

a) Each practical paper is of 45 marks, each containing four questions of 20 marks and student has to solve any two questions. Five marks are reserved for journal work

b) Duration of each practical paper is of four hours.

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

d) The project work should carry 20 marks .The marking system for project work is as follows:

i) Data collection -Five marks. ii) Analysis of data -Five marks.

iii) Report writing & conclusions. – Five marks. iv) Viva on project work. –Five marks.