SOLAPUR UNIVERSITY, SOLAPUR

CBCS Pattern Syllabus

B.Sc. Part III (Semester V and VI)

STATISTICS

w. e. f. June 2018

1) Preamble

SOLAPUR UNIVERSITY, SOLAPUR
CBCS Pattern Syllabus
B.Sc. Part III (Semester V and VI)
STATISTICS
w. e. f. June 2018

THEORY

Paper No.	Title of the Paper	University Exam.	Internal Exam.	Total
Semester V				
DSE-1A Statistics Paper-IX	Statistical Inference -I	70	30	100
DSE-2A Statistics Paper-X	Probability Distributions	70	30	100
DSE-3A Statistics Paper-XI	Sampling Techniques	70	30	100
SEC-1 Statistics Paper-XII	Operations Research	70	30	100
	OR			
SEC-2 Statistics Paper-XII	Regression Analysis	70	30	100
Semester VI				
DSE-1B Statistics Paper-XIII	Statistical Inference -II	70	30	100
DSE-2B Statistics Paper-XIV	Probability Theory	70	30	100
DSE-3B Statistics Paper-XV	Designs of Experiments	70	30	100
SEC-3 Statistics Paper-XVI	Quality Management and Reliability	70	30	100
	OR			
SEC-4 Statistics Paper-XVI	Time Series Analysis	70	30	100
			Total	800

Abbrivations :-

 # Skills Enhancement Course (SEC)
Geochemistry/Biochemistry/Meteorology/Plant Protection
 # Discipline Specific Elective (DSE)
Chemistry/Physics/Electronics/Computer Science/Mathematics/Statistics/Botany/Zoology/ Microbiology/Geology

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PRACTICAL

Practical	Paper No	Title of the Paper	U.A.				C.A.	Paper
			Marks	Journal	Oral	Total	Marks	Total
DSE-1A & 1B	IV	Statistical Inference	50	5	5	60	30	90
DSE-2A & 2B	V	Probability Distributions and R- Software	50	5	5	60	30	90
DSE-3A & 3B	VI	Designs of Experiments and Sampling Techniques	50	5	5	60	30	90
SEC-1,2	VII	SQC and Operations Research	50	5	5	60	30	90
OR								
SEC-3,4	VII	Regression And Time Series Analysis	50	5	5	60	30	90
Project Report and Viva-Voce								40
							Total	400

SCHEME OF TEACHING:

Sr. No.	Paper	Teaching Hours / Week		
		L	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:

(I) Total teaching periods for each theory papers in each semester are Three per week.

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

(III) **Scheme of evaluation:**

As per the norms of the grading system of evaluation, out of 100 Marks, the candidate has to appear for College internal assessment of 30 marks and external evaluation (University Assessment) of 70 marks. Assessment scheme is given below.

Semester - V:

Theory: (100 marks)

University Examination (70 Marks): No. of Theory papers: 4 Papers/Subject and Compulsory

English (Total 5 Papers)

Internal Continuous Assessment (30 Marks):

Scheme of Marking: 15 Marks: Internal Test

15 Marks: Home assignment/Tutorials/Seminars/ Group discussion/ Viva/Field visit/Industry visit.

(IV) Duration of University Examinations:

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

(V) **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 :10 Marks
- Analysis of Data :10 Marks
- Conclusion :10 Marks
- Viva on Project :10 Marks

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

2) Objectives :-

The main objective of this course is to develop the advanced statistical skills to the students, which covers concepts of statistical inference, design of experiment, sampling techniques, distribution theory, operation research, S.Q.C., regression analysis, time series analysis and R programming. 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 expect to

I)Distinguish between point estimation and interval estimation.

II) Understand and solve testing of hypothesis problems.

III) work out the design of experiments.

IV) Utilize various sampling techniques.

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

VI) Understand the concepts of stochastic process, queuing theory, and reliability theory.

VII) Understand concept of operation research, SQC, sampling plans.

VIII) Use of R software

IX) Know the utility of time series analysis and regression analysis.

X) To conduct project work to understand how to collect the data, analyze it and interpret it.

3. Nature of Question papers(Theory):

Solapur University, Solapur

Nature of Theory Question Paper

w. e. f. June 2018

Time: $2\frac{1}{2}$ hrs. **Total Marks-70**

Q.1) Multiple choice questions. **(14)**

i) ----------

a) b) c) d)

ii)
iii)
iv)
v)
vi)
vii)
viii)
ix)
x)
xi)
xii)
xiii)
xiv)

Q.2) Answer any Seven from the following **(14)**

a)
b)
c)
d)
e)
f)
g)
h)
i)

Q.3) A) Answer any Two from the following **(10)**

a)
b)
c)

Q.3) B) (4)

Q.4) Attempt any Two from the following (14)

A)
B)
C)

Q.5) Attempt any Two from the following (14)

A)
B)
C)

4. Nature of practical papers:

(i) Each Practical Question paper must contain **Four** questions of **25 marks each**.

(ii) Each question should contain **Two** bits from different units of **13 and 12 marks** respectively.

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

(iv) Each question bit to be distributed according to following Points:

(a) Aim of the Experiment 2 Marks

(b) Statistical formulae 2 Marks

(c) Observation Tables 3/2 Marks

(d) Calculations 4 Marks

(e) Conclusion/result of the experiment 2 Marks.

5. Instructions

(i) While attempting questions based on R-software students have to write the commands of R-software on their Answer-book. Final result should be shown to the examiner on line or the printout may be attached.

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

(iii) Student can use MS-Excel or electronic calculators for other practical.

6. 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).

CBCS Pattern Syllabus: DSE - 1A

B.Sc. III Statistics Semester V Paper IX

Statistical Inference-I

Unit-1:Point Estimation (15)

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

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

1.3: 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 $\varphi(T)$ 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.

1.4: 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.

1.5: Consistency: Definition, proof of the following:

(a)Sufficient condition for consistency,

(b)If T is consistent for θ and $\varphi(.)$ is a continuous function then $\varphi(T)$ is consistent for $\varphi(\theta)$. Illustrative examples

Unit-2:LikelihoodandSufficiency(12)

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

2.2: 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 $\varphi(T)$ is also sufficient for θ provided $\varphi(.)$ is a one-to-one and on-to function. (b) If T is sufficient for θ then T is sufficient for $\varphi(\theta)$.

2.3: Fisher information function: Definition of information function, amount of information contained in a sample. Statement regarding equality of the information in $(x_1,x_2,.....,x_n)$ and in a sufficient statistic T, concept of minimal sufficient statistic.

With illustrations to exponential family.

2.4: 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.

(iii) Examples and problems.

Unit-4: Methods of Estimation (11)

4.1: 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.

4.2: 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 (for uniform distribution). Illustrative examples.

4.3: 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. Casela G. and Berger R.L.: Statistical Inference.
14. Siegel, S.: Non-parametric Methods for the Behavioral Sciences.
15. Dr. P. G. Dixit, Dr. (Mrs.) V. R. Prayag, S. M. Patil, N. J. Subandh: Statistical Inference: Estimation, Nirali Prakashan, Pune

CBCS Pattern Syllabus: DSE - 2A

B.Sc. III Statistics Semester V Paper X

Probability Distributions

Unit-1: Univariate Continuous Probability Distributions (15)

1.1 **Laplace (Double Exponential) Distribution :** P.d.f. with parameters (μ, λ), Nature of the probability curve, Distribution function, quartiles, m.g.f., mean, variance, moments, β_1, β_2, γ_1 and γ_2, Laplace distribution as the distribution of the difference of two i.i. d. exponential variates with parameter θ, examples and problems.

1.2 Lognormal Distribution: P. d. f. with parameters (μ,σ^2), Nature of the probability curve, mean, variance, median, mode, moments, β_1, β_2, γ_1 and γ_2 coefficients, Relation with N(μ,σ^2), examples and problems.

1.3 Cauchy Distribution: P.d.f. with parameters (μ , λ), nature of the probability curve, distribution function, quartiles, non-existence of moments, additive property for two independent Cauchy variates (statement only), statement of distribution of the sample mean, relationship with uniform and Students 't' distribution, distribution of X/Y where X and Y are i.i.d. N(0,1), examples and problems.

1.4 Weibull Distribution: P. d.f. with parameters (α, β), distribution function, quartiles, mean and variance, coefficient of variation, relation with gamma and exponential distribution, examples and problems.

Unit-2:Univariate and Multivariate Probability Distributions (12)

2.1 Logistic distribution: p. d. f. with parameters (μ, σ), c. d. f., mean, mode, variance, skewness using mode, applications.

2.2 Paroto distribution: p. d .f. with parameters (α , β), mean, variance, mode, skewness using mode, applications.

2.3 Power series distribution: p. m. f. mean, mode, variance, Binomial, Poisson, Geometric and negative binomial distribution as particular cases of power series distribution.

Unit-3:Truncated Distributions (8)

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

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

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

3.4 Normal distribution N(μ,σ^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.

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

3.6 Examples and problems.

Unit-4: Bivariate Normal Distribution **(10)**

4.1 p.d.f. of a bivariate normal distribution, $BN(\mu_1, \mu_2, \sigma_1^2, \sigma_2^2, \rho)$, 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.

4.2 Cauchy distribution as the distribution of Z = X/Y where, $(X,Y) \sim BN(0,0,\sigma_1^2,\sigma_2^2,\rho)$

4.3 Examples and problems.

Books Recommended:

1. CramerH.: Mathematical Methods of Statistics, Asia Publishing House, Mumbai.
2. Mood,A.M., GraybillK, 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. 866,34dAvenue, 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, 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.

CBCS Pattern Syllabus: DSE - 3A
B.Sc. III (Statistics) Semester V Paper XI
Sampling Techniques

Unit–1: Basic Terminology and Simple Random Sampling (15)

1.1: Basic Terminology:

Concept of distinguishable elementary units, sampling units, sampling frame, random sampling and non-random sampling. Advantages of sampling method over census method, objectives of a sample survey, Designing a questionnaire, Characteristics of a good questionnaire, Concept of sampling and non-sampling errors. Handling of non-response cases.

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 expectation, 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 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. 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 **(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 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 **(5)**

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.

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.

CBCS Pattern Syllabus: SEC - 1
B.Sc. III (Statistics) Semester V Paper XII
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-degenerate 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.

iii. Examples and problems.

1.3:DualityTheory:

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

ii. Examples and problems.

Unit-2: Transportation and Assignment Problems (12)

2.1: Transportation problem :

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

ii. Methods of obtaining initial basic feasible solution of T.P. (a) North West corner rule (b) Method of matrix minima (least cost method), (c) 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.

iv. Examples and problems.

Unit-3: 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.

Unit.4: Simulation Techniques **(10)**

Meaning of simulation, Monte Carlo simulation, advantages and disadvantages of simulation, definition and properties of random numbers, generation of pseudorandom numbers, Techniques of generating random numbers from uniform distribution, Tests for randomness and uniformity, random variate generation using inverse c. d. f. method, random variate generation from Bernoulli, Binomial, Poisson, Geometric, Exponential and normal distributions.

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 Mc Graw 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.Luc Devroye: Non-Uniform Random Variate Generation, Springer–Verlag, NewYork.

11.Gentle, J.E.: Random Number Generation and Monte Carlo Methods, Springer- Verlag.

12. Robert, C.P. and Casella, G.: Monte Carlo Statistical methods, Springer-Verlag.

13. Rubinstien, R.Y.: Simulation and Monte Carlo Method, John Wiley, New York.

CBCS Pattern Syllabus: SEC - 2

B.Sc. III (Statistics) Semester V Paper XII

Regression Analysis

1. Simple linear regression model (16)

i) Review of simple linear regression model : $Y = \beta_0 + \beta_1 X + \epsilon$, where ϵ is a continuous random variable with $E(\epsilon) = 0$ and $V(\epsilon) = \sigma^2$. Estimation of β_0 and β_1, by the method of least squares.

ii) Properties of estimators of β_0 and β_1

iii) Estimation of σ^2

iv) Assumption of normality of ϵ . Tests of hypothesis of β_1.

v) Interval estimation in simple regression model

vi) Coefficient of determination

vii) Residual Analysis. Standardised residuals, Studentized residuals, residual plot

viii) Detection and treatment of outliers.

ix) Interpretation of four plots produced by LM command in R

2. Review of multiple Regression Model (20)

i) Review of multiple linear regression model : $Y = \beta_0 + \beta_1 X_1 + \ldots + \beta_p Xp + \epsilon$, where ϵ is a continuous random variable with $E(\epsilon) = 0$ and $V(\epsilon) = \sigma^2$

ii) Estimation of regression parameters $\beta_0 , \beta_1, \ldots . , \beta_p$ by method of least square, obtaining normal equations

iii) Estimation of σ^2

iv) Assumption of normality of ϵ . Tests of hypothesis of regression parameters.

v) Interval estimation in simple linear regression model.

vi) Variable selection and model building.

vii) Residual diagnostics and corrective measures such as transformation of response variable, weighted least squares method.

3. Logistic Regression Model (9)

i) Binary response variable

ii) logit transform

iii) estimation and interpretation of parameters

iv) Tests of hypotheses of model parameters, model deviance, LR test.

Book Recommended

1) Montgomery D.C., Peak E.A. , And Vining G.G. (2003). Introduction to Linear Regression Analysis (Wiley)

2) Hosmer D.W. And Lemeshow, S. (1989). Applied Logistic Regression (Wiley)

3) Manisha Sane, Regression Analysis : Nirali Prakashan

CBCS Pattern Syllabus : DSE - 1B

B.Sc. III Statistics Semester VI Paper XIII

Statistical Inference - II

Unit-1:Interval Estimation (11)

1.1: 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.

1.2: Interval estimation for the following cases :

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

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

(iii) Difference between two means μ_1-μ_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 exponential 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 (13)

2.1: 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, p-value, size of a test, level of significance, problem of controlling probabilities of type I & type II errors.

2.2: 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 M P test. Examples of construction of MP test of level α.

2.3: 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.

2.4: Likelihood Ratio Test : Procedure of likelihood ratio test, statement of its properties, Likelihood Ratio test involving mean and variance of normal population.

Unit-3:SequentialTests (9)

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-parametricTest **(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 sample problems.

(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

(vi) 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.

CBCS Pattern Syllabus: DSE -2B

B.Sc. III Statistics Semester VI Paper XIV

Probability Theory

Unit-1: Order Statistics (10)

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

Unit-2: Convergence and Limit Theorem (12)

2.1: Convergence:

i. Definition of convergence of sequence of random variables (a) in probability, (b) in distribution, (c) 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.

2.2: 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-3: Finite Markov Chains (12)

3.1: 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, Examples and problems.

3.2: 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. Examples and problems.

3.3: Continuous Markov chain:

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

ii. Examples and problems.

Unit-4: Queuing Theory (11)

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 distributions 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. Examples and problems.

Books Recommended

1. Cramer H.: Mathematical Methods of Statistics, Asia Publishing House, Mumbai.
2. Lindgren B.W .: Statistical Theory (Third Edition), Collier Macmillan International Edition, Macmillan Publishing Co. Inc. New York.
3. Hogg, R.V. and Craig A.T .: Introduction to Mathematical Statistics (Third Edition), Macmillan Publishing Company, Inc. 866, 34 d Avenue, New York, 10022.
4. Sanjay Arora and BansiLal : New Mathematical Statistics (First Edition), Satya Prakashan 16/17698, New Market, New Delhi, 5(1989).
5. Gupta S. C and Kapoor V. K. : Fundamentals of Mathematical Statistics, Sultan Chandand Sons, 88, Daryaganj, New Delhi 2.
6. Rohatgi V.K. : An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
7. Medhi J : Stochastic Processes. Wiley Eastern Ltd. New Delhi.
8. Hoel, Port and Stone : Introduction to Stochastic Processes, Houghton Mifflin.
9. Feller. W. : An Introduction to Probability Theory and its Applications. Wiley Eastern Ltd. Mumbai.
10. Bhat B.R. : Modern Probability Theory.
11. Karlin and Taylor : Stochastic Process.
12. Ross S : Probability Theory.
13. Bhat B.R.: Stochastic Models : Analysis and Applications. New Age International.
14. Zacks S.: Introduction to Reliability Analysis, Probability Models and Statistical Methods, Springer Verlag.
15. Taha H.A. : Operation research– An Introduction, Fifth edition, Prentice Hall of India, New Delhi.
16. Barlow R.E. and Proschan Frank : Statistical Theory of Reliability and Life Testing. Holt. Rinebartand Winston Inc., New Yark
17. Sinha S.K. : Reliability and Life Testing, Second Edition, Wiley Eastern Publishers, New Delhi.
18. Trivedi R. S. : Probability and Statistics with Reliability and Computer Science Application, Prentice–Hall of India Pvt. Ltd., New Delhi.
19. Parimal Mukhopadhyaya : An Introduction to the Theory of Probability. World Scientific Publishing.

CBCS Pattern Syllabus : DSE - 3B

B. Sc. III (Statistics) Semester VI Paper XV

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.

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 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 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. 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 lay out in total confounding and partial confounding in 2^3 factorialexperiment.

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.

CBCS Pattern Syllabus : SEC - 3

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

Quality Management and Reliability Theory

Unit.1:Quality Tools: (10)

Meaning and dimensions of quality, quality philosophy, Magnificent tools of quality: Histogram, Check sheet, Pareto diagram, cause and effect diagram, scatter diagram, control chart, flow chart. Deming's PDCA cycle for continuous improvements and its applications.

Unit2: Process Control: (12)

CUSUM chart, tabular form, use of these charts for monitoring process mean. Moving average and exponentially weighted moving average charts. Introduction to six-sigma methodology, DMAIC cycle and case studies.

Unit3:Product Control (13)

Sampling Inspection plans for attribute inspection: Concept of AQL, LTPD, Consumer's risk, producer's risk, AOQ, AOQL, OC, ASN and ATI. Description of Single and double sampling plans with determination of above constants.

Unit-4: Reliability Theory. (10)

(i) Binary system : Block diagram, definition of binary coherent structure and illustrations. Coherent system of component (at most three) , a) Series b) Parallel c) 2 out of 3 system.

(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. 'S' shapedness property of h (p) without proof.

(iv) Ageing Properties: Definitions, Hazard rate, hazard function, survival function, concept of distributions with increasing and decreasing failure rate (IFR,DFR).

v) 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.

vi) Examples on exponential and Weibull distributions.

Books Recommanded

1. Introduction to quality Control–Montgomery D.C.
2. Quality Control and Industrial statistics Duncan A J
3. Statistical Quality Control by E L Grant
4. Zacks S.: Introduction to Reliability Analysis, Probability Models and Statistical
5. Barlow, R.E. and Proschan Frank: Statistical Theory of Reliability and Life Testing, Holt Rinebart and Winston Inc., New York.
6. Sinha S.K.: Reliability and Life Testing, Second Edition, Wiley Eastern Ltd. New Delhi.
7. Trivedi R.S.: Probability and Statistics with Reliability and Computer Science Application, Prentice – Hall of India Pvt. Ltd., New Delhi.
8. Dr. B.G. Kore and Dr. P. G. Dixit: Statistical Methods-II, 4thEdition, December, 2017, Nirali Prakashan, Pune.

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

Time Series Analysis

Unit 1: Features of time series data (10)

1.1) Meaning and utility of time series.

1.2) Components of time series - trend, seasonal variation, cyclical variations, irregular (random) fluctuations

1.3) studying a given series by plots and histograms

1.4) Test of randomness of a series against trend and seasonality

Unit 2 : Methods of trend estimation and smoothing : (18)

2.1) moving average

2.2) curve fitting by least square principle

2.3) exponential smoothing

2.4) forecasting based on smoothing

2.5) double exponential smoothing

2.6) Choosing parameters for smoothing and forecasting

2.7) Estimating mean square error of forecasting

2.8) Prediction intervals based on normality assumption.

Unit 3 : Measurement of seasonal variations : (8)

3.1) Simple average method

3.2) ratio to moving average method.

Unit 4: Time series Analysis Through Regression (9)

4.1) Regression models for trend and seasonality

4.2) De-trending and de-seasonalizing a series

4.3) Fitting of auto-regressive models AR(1) and AR(2)

4.4) plotting of residuals

4.5) examples and problems

Books Recommended

1. Montgomery , D.C. and Johnson L.A. (1976) : Forecasting and Time series Analysis, McGraw Hill.
2. The Analysis of Time Series An Introduction Sixth Edition : Chris Chatfield CRC press Taylor and Francis Group , A Chapman And Hall Book
3. Farmum, N. R. and Stantorr, L.W. (1989). Quantitative Forecasting Methods, PWS-Kent Publishing Company, Boston.
4. Dr. B.G. Kore and Dr. P. G. Dixit: Statistical Methods-I : Nirali Prakashan, Pune.

CBCS Pattern Syllabus : B.Sc. III (Statistics) Practical Paper IV

Probability Distributions and R-Software

1) Model sampling from Laplace distribution.
2) Model sampling from pareto distribution
3) Model Sampling from Cauchy distribution
4) Model sampling from truncated binomial and poison distributions.
5) Model sampling from truncated normal and exponential distributions.
6) Model sampling from bivariate normal distribution.
7) Fitting of truncated binomial distribution.
8) Fitting of truncated Poisson distribution.
9) Application of multinomial distribution.
10) Application of bivariate normal distribution.
11) Data input/output, diagrammatic and graphical representation of data using R-Software.
12) Computation of probabilities of type I and type II errors and power of a test using R-Software.
13) Model sampling from log-normal and Weibull distributions using R-Software.
14) Model sampling from logistic distribution using R-Software.
15) Fitting of Binomial and Poisson distributions using R-Software.
16) Fitting of Normal distribution using R-Software.
17) Fitting of log-normal distribution using R-Software.
18) Analysis of Completely Randomized Design (CRD) using R-Software.

    Analysis of Randomized Block Design (RBD) using R-Software.

Books Recommended:

1. Sudha G. Purohit, Sharad D. Gore and Shailaja R. Deshmukh: Staistics Using R.

2.Verzani:Using R for introductory Statistics.

3. V. R. Pawagi : Staistical Computing Using R Software

CBCS Pattern Syllabus : B.Sc. III (Statistics) Practical Paper 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, graphical representation of procedure.
13. Construction of SPRT for exponential and normal distribution, graphical representation of procedure.
14. NPtest—Runtest (for one and two independent samples).
15. NPtest–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. NPtest–Median test (for two large independent samples)
18. NP test—Kolmogorov-smirnov test (for one and two independent samples).

CBCS Pattern Syllabus : B.Sc. III (Statistics) Practical Paper VI

Design of Experiments and Sampling Techniques

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 Attributes.
11. Determination of Sample Size in SRS for Variables and Attributes.
12. Stratified Random Sampling–I
13. Stratified Random Sampling–II
14. Ratio Method of Estimation.
15. Regression Method of Estimation.
16. Systematic Sampling.
17. Cluster Sampling.
18. Two Stage and Multi Stage Sampling.

CBCS Pattern Syllabus : B.Sc. III (Statistics) Practical Paper VII

Operations Research, Quality Management and Reliability Theory

1. L.P.P. by simplex method I (Slack variable)
2. L.P.P. by simplex method II (Big M method)
3. Transportation problem-I.
4. Transportation problem-II.(Degeneracy)
5. Assignment problem.
6. Sequencing Problem.
7. Decision Theory.
8. Simulation I (Discrete distribution)
9. Simulation II (Continuous distribution)
10. EWMA-Chart.
11. CUSUM chart.
12. Six sigma limits for mean.
13. Single sampling plan-I (Small sample).
14. Single sampling plan-II (Large sample).
15. Double sampling plan-I (Small sample).
16. Double sampling plan-II (Large sample).
17. Reliability Theory-I (Block diagram, Structure function, Minimal cut, Minimal path, Reliability)
18. Reliability Theory-II (Hazard rate, Hazard function, Survival function, IFR,DFR, Examples on Exponential and Weibull distributions)

CBCS Pattern Syllabus : B.Sc. III (Statistics) Practical Paper VII

Regression Analysis And Time Series Analysis

1) Estimation of β_0 and β_1, by the method of least squares in simple regression model.
2) Estimation of σ^2 in simple regression model
3) Tests of hypothesis of β_1 under Assumption of normality of ϵ, in simple regression model .
4) Interval estimation in simple regression model
5) Residual Analysis. Standardised residuals, Studentized residuals, residual plot in simple regression model
6) Estimation of regression parameters $\beta_0, \beta_1, \ldots, \beta_p$ by method of least square, obtaining normal equations, in multiple regression model
7) Estimation of σ^2 in multiple regression model
8) Tests of hypothesis of regression parameters, in multiple regression model.
9) Tests of hypotheses of model parameters, model deviance, LR test in multiple regression model.
10) Study of time series : plots and histogram
11) Test of randomness of a series against trend and seasonality
12) Trend estimation using moving average
13) Curve fitting by least square method
14) Trend estimation using smoothing
15) Measurement of seasonal variation by Simple average method
16) Measurement of seasonal variation by ratio to moving average method.
17) Fitting of trend by AR(1) mode
18) Plotting of residuals