Deccan Education Society's
FERGUSSON COLLEGE (AUTONOMOUS),
PUNE

Syllabus

for

S. Y. B. Sc. (Statistics)

[Pattern 2019]

(B.Sc. Semester-III and Semester-IV)

From Academic Year

2020-21

Deccan Education Society's
Fergusson College (Autonomous), Pune

S.Y.B.Sc. Subject (Pattern 2019)

From academic year 2020-21

Particulars	Name of Paper	Paper Code	Title of Paper	No. of Credits
S.Y. B.Sc. Semester III	Theory Paper - 1	STS 2301	Sampling Techniques	2
	Theory Paper - 2	STS 2302	Probability Theory and Distributions – II	2
	Practical Paper - 1	STS 2303	Statistics Practical -III	2
S.Y. B.Sc. Semester IV	Theory Paper - 3	STS 2401	Sampling Distributions	2
	Theory Paper - 4	STS 2402	Statistical Methods – II	2
	Practical Paper - 2	STS 2403	Statistics Practical -IV	2

Course Outcomes (COs)

S.Y. B.Sc. Semester III		
Title of the Course and Course Code	**Sampling Techniques (STS2301)**	**Number of Credits : 02**
On completion of the course, the students will be able to:		
CO1	Recall concepts of sample and population, various sampling methods	
CO2	Explain simple random sampling for variables and attributes, need of construction of strata and allocation problems in stratified random sampling method, sampling and non-sampling errors, PPS sampling	
CO3	Choose a sample of suitable size by using various sampling methods to collect data in day today life,	
CO4	Calculate estimates of unbiased estimators and their standard errors in various sampling methods.	
CO5	Compare simple random sampling, stratified random sampling and systematic sampling	
CO6	Design a questionnaire to carry out sample survey	

Unit No.	Title of Unit and Contents	No. Of. Lectures
I	**Basic concepts:** 1.1 Population and sample, census and sample survey, sampling frame, sampling design, random sample, requisites of a good sample. 1.2 Sample surveys, principles of sample survey, planning and execution of sample survey, sampling and non-sampling errors. 1.3 Advantages and limitations of sampling. 1.4 Sample survey versus complete enumeration.	**6**
II	**Simple Random Sampling (with and without replacement):** 2.1 Notations and terminology, various probabilities of selection. 2.2 Sample mean($\bar{y}$) as an estimator of population mean, Derivation of expectation and standard error of ($\bar{y}$), confidence interval for population mean, population total, derivation of expectation and standard error of $N\bar{y}$ as an estimator of population	**12**

	total Estimation of above standard errors in case of SRSWOR and SRSWR 2.3 Simple random sampling of attributes. Sample proportion(p) as an estimator of population proportion of units possessing a certain attribute, derivation of expectation and standard error of (p) Estimator (Np) as an estimator of total number of units in the population possessing a certain attribute, derivation of expectation and standard error of (Np), Estimator of above standard error in case of SRSWOR and SRSWR 2.4 Determination of sample size for the given (i) margin of error and confidence coefficient (ii)coefficient of variation of the estimator and confidence coefficient.	
III	**Stratified random sampling:** 4.1 Principles of stratification, notations. 4.2 Estimator ($\bar{y}_{st}$) of population mean, derivation of its expectation and standard errorcost function. Estimator ($N\bar{y}_{st}$) of population total, derivation of its expectation and standard error 4.3 Allocation techniques: proportional and optimum allocations derivation of expressions for the standard errors of the above estimators 4.4 Comparison of stratified sampling with simple random sampling. 4.5 Cost and variance analysis, minimization of variance for the fixed cost and minimization of cost for the fixed variance. Neyman's allocation as a special case of optimum allocation in cost and variance analysis.	**12**
IV	**Probability proportional to size (PPS) sampling and Systematic sampling:** 3.1 Definition and terminology. 3.2 Cumulative total method and Lahiri's methods of selecting PPS sampling with and without replacement. 3.3 Systematic sampling procedure, estimator of population mean, derivation of its expectation and standard error, 3.4 Systematic sampling from population with linear trend. 3.5 Comparison of systematic sampling with simple random sampling in case of population with linear trend. .	**6**

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1. Ardilly, P. and Yves T. (2006). Sampling Methods: Exercise and Solutions. Springer.
2. Cochran, W.G. (2007). Sampling Techniques. (Third Edition). John Wiley & Sons, New Delhi.
3. Des Raj. (1976). Sampling Theory. Tata McGraw Hill, New York. (Reprint 1979)
4. Mukhopadyay, P. (2007). Survey Sampling. Narosa Publisher, New Delhi. Alpha Science International Ltd.
5. Sampth, S. (2005). Sampling Theory and Methods, 2nd Edition
6. Singh, D. and Choudhary, F.S. (1977). Theory and Analysis of Sample Survey Designs. Wiley Eastern Ltd, New Delhi. (Reprint 1986)
7. Sukhatme, P.V. and Sukhatme, B.V. (1970). Sampling Theory Surveys with Applications (Second Edition). Iowa State University Press.
8. Thompson, S.K. (2012). Sampling. John Wiley & Sons.

Title of the Course and Course Code	**Probability Theory and Distributions – II (STS2302)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define continuous random variable , its probability density function and its characteristics such as expectation, variance and higher order moments.	
CO2	Explain the theory and application of important continuous distributions such as uniform, normal, exponential and bivariate probability distributions.	
CO3	Apply different methods to obtain probability distribution of transformation of random variables.	
CO4	Analyze the real life situations of continuous probability distributions.	
CO5	Make judgments / comparisons through normal probability and q-q	

	plots for testing normality of data obtained in real life situations.
CO6	Constitute an appropriate statistical model in case of practical situations.

Unit No.	Title of Unit and Contents	No. Of. Lectures
I	**Continuous univariate probability distributions**	**13**
	1.1 Continuous sample space: Definition, illustrations Continuous random variable: Definition, probability density function (p.d.f.), distribution function (d.f.), properties of d.f. (without proof), probabilities of events related to random variable 1.2 Expectation of continuous r.v., expectation of function of r.v. E[g(X)], variance, geometric mean, harmonic mean, raw and central moments, skewness, kurtosis 1.3 Moment generating function (m.g.f.): Definition and its properties, Cumulant generating function (c.g.f.): Definition and its properties 1.4 Mode, median, quartitles 1.5 Probability distribution of function of a r. v. : Y = g(X) using i) Jacobian of transformation for g(.) monotonic function and one-to-one, on to functions, ii) Distribution function for $Y = X^2$, Y = |X| etc., iii) m.g.f. of g(X)	
II	**Standard Continuous Probability Distributions**	**13**
	2.1 Motivation for distribution theory – Presentation 2.2 Uniform or rectangular distribution: probability density function (p.d.f.) $f(x) = \begin{cases} \frac{1}{b-a}, a \le x \le b \\ 0 \ , \text{ otherwise} \end{cases}$ Notation : X ~ U[a, b] Sketch of p. d. f., Nature of p.d.f., d. f., mean, variance Distribution of i) $\frac{X-a}{b-a}$, ii) $\frac{b-X}{b-a}$ iii) Y = F(x) where F(x) is distribution function of a continuous r.v., applications of the result for model sampling. 2.3 Normal distribution: probability density function (p. d. f.) $f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(\frac{-1}{2\sigma^2}(x-\mu)^2\right)$, $-\infty < x < \infty$, $-\infty < \mu < \infty$; $\sigma > 0$ Notation: $X \sim N(\mu, \sigma^2)$ identification of location and scale parameters, nature of probability curve, mean , variance, m.g.f., c.g.f., central moment , cumulants, β_1 , β_2 , γ_1, γ_2 , median, mode, quartiles, mean deviation,	

	additive property, computations of normal probabilities using normal probability integral tables, probability distribution of : i) $\frac{X-\mu}{\sigma}$, standard normal variable (S.N.V.), ii) aX + b, iii) aX + bY + c, iv) X^2 , where X and Y are independent normal variables. Probability distribution of $\bar{X}$, the mean of n i. i. d. $N(\mu,\sigma^2)$ r. v s. Normal probability plot, q-q plot to test normality. Model sampling from Normal distribution using (i) Distribution function method and (ii) Box-Muller transformation as an application of simulation. Statement and proof of central limit theorem (CLT) for i. i. d. r. v. s with finite positive variance.(Proof should be using m.g.f.) Its illustration for Poisson and binomial distributions. 2.4 Exponential distribution: probability density function (p. d. f.) $f(x) = \begin{cases} \alpha e^{-\alpha x} , & x > 0 , \alpha > 0 \\ 0 & \text{otherwise} \end{cases}$ Notation : $X \sim Exp(\alpha)$ 2.5 Nature of p.d.f., mean, variance, m.g.f., c.g.f., d. f., graph of d . f., lack of memory property, median, quartiles. Distribution of min(X, Y) where X and Y are i. i. d. exponential r.v.s	
III	**Continuous Bivariate Probability distributions**	**10**
	3.1 Continuous bivariate random vector or variable (X, Y): Joint p.d.f. , joint d.f. , properties (without proof), probabilities of events related to r.v. (events in terms of regions bounded by regular curves, circles, straight lines) Marginal and conditional distributions	
	3.2 Expectation of r.v., expectation of function of r.v. E[g(X, Y)], joint moments, Cov (X,Y), Corr (X, Y), conditional mean, conditional variance, E[E(X|Y = y)] = E(X), regression as a conditional expectation	
	3.3 Independence of r. v. (X, Y) and its extension to k dimensional r.v. Theorems on expectation: i) E(X + Y) = E(X) + E(Y), (ii) E(XY) = E(X) E(Y) , if X and Y are independent r.v.s , generalization to k variables E(aX + bY + c), Var (aX + bY + c)	
	3.4 Joint m.g.f. $M_{X, Y}(t_1 , t_2)$, m.g.f. of marginal distribution of r.v.s., and following properties (i) $M_{X ,Y}(t_1,t_2) = M_X (t_1,0) M_Y (0, t_2)$, if X and Y are independent r.v.s (ii) $M_{X+Y}(t) = M_{X , Y}(t , t)$,	

	(iii) $M_{X+Y}(t) = M_X(t)\, M_Y(t)$ if X and Y are independent r.v.s
	3.5 Probability distribution of transformation of bivariate r. v. $U = \phi_1(X, Y)$, $V = \phi_2(X, Y)$

References:

1. Goon A. M., Gupta, M. K. and Dasgupta, B. (1986), *Fundamentals of Statistics, Vol. 2*, World Press, Kolkata.
2. Gupta, S. C. and Kapoor, V. K. (2002), *Fundamentals of Mathematical Statistics*, (*Eleventh Edition*), Sultan Chand and Sons, 23, Daryaganj, New Delhi , 110002 .
3. Gupta, S. C. and Kapoor V. K. (2007), *Fundamentals of Applied Statistics* (*Fourth Edition*), Sultan Chand and Sons, New Delhi.
4. Hogg, R. V. and Craig, A. T. , Mckean J. W. (2012), *Introduction to Mathematical Statistics (Tenth Impression*), Pearson Prentice Hall.
5. Medhi, J., *Statistical Methods*, Wiley Eastern Ltd., 4835/24, Ansari Road, Daryaganj, New Delhi – 110002.
6. Meyer, P. L., *Introductory Probability and Statistical Applications*, Oxford and IBH Publishing Co. New Delhi.
7. Mood, A. M., Graybill F. A. and Bose, F. A. (1974), *Introduction to Theory of Statistics (Third Edition, Chapters II, IV, V, VI*), McGraw - Hill Series G A 276
8. Mukhopadhya Parimal (1999), *Applied Statistics*, New Central Book Agency, Pvt. Ltd. Kolkata
9. Ross, S. (2003), *A first course in probability (Sixth Edition*), Pearson Education publishers , Delhi, India.
10. Walpole R. E., Myers R. H. and Myers S. L. (1985), *Probability and Statistics for Engineers and Scientists (Third Edition, Chapters 4, 5, 6, 8, 10)*, Macmillan Publishing Co. Inc. 866, Third Avenue, New York 10022.
11. Weiss N., *Introductory Statistics*, Pearson education publishers.

Title of the Course and Course Code	Statistics Practical-III (STS2303)	Number of Credits : 02

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1	Recall the commands of R software
CO2	Illustrate the random sampling procedures and fitting probability distributions to real life situations.
CO3	Apply the procedure of drawing random samples for continuous probability distributions.
CO4	Generate various probabilities of events using commands of R-software.
CO5	Justify cost and variance analysis for allocation of sample size on various strata
CO6	Plan statistical analysis of primary / secondary data using R

Sr. No.	Title of the experiment
1.	Simple random sampling for population mean, population total (i)with replacement , (ii) without replacement
2.	Simple random sampling for proportions: (i)with replacement , (ii) without replacement
3.	Stratified random sampling : Proportional and Neyman allocation, comparison with SRSWOR
4.	Stratified random sampling : cost and variance analysis
5.	Fitting of normal distributions, plot of observed and expected frequencies
6.	Applications of uniform and exponential distributions
7.	Applications of normal distributions
8.	Model sampling from normal distribution using distribution function and Box-Muller transformation
9.	Model sampling from exponential distribution
10.	Computation of probabilities for normal , exponential, probability distributions using R software
11., 12..	} Statistical analysis of primary/secondary data using R- software

S.Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Sampling Distributions - (STS2401)**	**Number of Credits : 02**

Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Recall continuous random variable and its probability distribution
CO2	Develop the theory of sampling distribution of statistics.
CO3	Apply the derived probability distributions to real life situations.
CO4	Analyze the real life situations using derived probability distributions.
CO5	Justify the use of truncated normal distribution.
CO6	Synthesize an appropriate statistical model in case of real life situations.

Unit. No.	Title of Unit and Contents	No. Of Lectures
I	**Chi-square (χ_n^2) Distribution:** 1.1 Definition of chi-square (χ^2) r. v. as sum of squares of i. i. d. standard normal variates, derivation of p.d.f. of χ^2 with n degrees of freedom using m.g.f., nature of probability. curve with the help of R software, computations of probabilities using tables of χ^2 distribution mean, variance, m.g.f., c.g.f., central moments, β_1, β_2 , γ_1, γ_2 , mode,additive property 1.2 Normal approximation: $\frac{\chi_n^2 - n}{\sqrt{2n}}$ with proof using m.g.f , Fisher'snormal approximation (without proof) 1.2 Distribution of $\frac{X}{X+Y}$ and $\frac{X}{Y}$ where X and Y are two independent chi- square random variables	**10**
II	**Student's t distribution:** 2.1 Definition of student's t distribution with n d. f. where $t = \frac{U}{\sqrt{V/n}}$, U and V are independent random variables such that U ~ N(0, 1) , V ~ χ_n^2 2.2 Derivation of p.d.f., nature of probability curve, mean, variance,	**8**

	moments, mode, use of tables of t-distribution for calculation of probabilities, statement of normal approximation	
III	**Snedecor's F-distribution:** 3.1 Definition of F r.v. with n_1 and n_2 d.f. as $Fn_1, n_2 = \frac{U/n_1}{V/n_2}$ where U and V are independent chi square random variables with n_1 and n_2 d.f. respectively 3.2 Derivation of p.d.f., nature of probability curve, mean, variance, moments, mode 3.3 Distribution of 1/ Fn_1, n_2 , use of tables of F-distribution for calculation of probabilities 3.4 Interrelations among, χ^2 , t and F variates	**9**
IV	**Sampling Distributions:** 4.1 Random sample from a distribution of r.v. X as i. i. d. r. v.s. $X_1, X_2, \ldots, X_n$ 4.2 Notion of a statistic as function of $X_1, X_2, , X_n$ with illustrations 4.3 Sampling distribution of a statistic. concept of sampling variation illustration (using R-software). Distribution of sample mean $\bar{X}$ of a random sample from normal population, exponential and gamma distribution. Notion of standard error of a statistic, illustration using (R-software) 4.4 Distribution of $\frac{nS^2}{\sigma^2} = \frac{1}{\sigma^2}\sum_{i=1}^{n}(X_i - \bar{X})^2$ for a sample from a normal distribution using orthogonal transformation. Independence of $\bar{X}$ and S^2	**9**

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1. Goon A. M., Gupta, M. K. and Dasgupta, B. (1986), *Fundamentals of Statistics, Vol. 2*, World Press, Kolkata.
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4. Gupta, S. P. (2002), *Statistical Methods* (*Thirty First Edition*), Sultan Chand and Sons, 23, Daryaganj, New Delhi 110002.
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7. Medhi, J., *Statistical Methods*, Wiley Eastern Ltd., 4835/24, Ansari Road, Daryaganj,

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11. Purohit S. G., Gore S. D. and Deshmukh S. R. (2008), *Statistics using R,* Narosa Publishing House, New Delhi.
12. Ross, S. (2003), *A first course in probability (Sixth Edition*), Pearson Education publishers , Delhi, India.
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14. Weiss N., *Introductory Statistics*, Pearson education publishers.

Title of the Course and Course Code	**Statistical Methods – II (STS2402)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall the concept of point estimation , unbiased estimator	
CO2	Discuss and define the terms used in testing of hypotheses.	
CO3	Compute probabilities of type I and type II error.	
CO4	Identify the distributions of various test statistics.	
CO5	Decide the appropriate hypotheses for testing the population parameters like mean , variance , correlation , proportion.	
CO6	Construct the tests about various population parameters and test goodness of fit of probability distributions.	

Unit. No.	Title of unit and Contents	No. of. Lectures
I	Theory of estimation and testing of hypothesis: 1.1 Statistics and parameters, statistical inference: problem of estimation and testing of hypothesis. Estimator and estimate. Unbiased estimator (definition and illustrations only), obtaining estimator by method of moments. 1.2 Statistical hypothesis, null and alternative hypothesis, simple and composite hypothesis, one sided and two sided alternative hypotheses, critical region, type I error, type II error, power of the test, level of significance, p-value.	**8**
II	2.1 One sample and two sample tests for mean(s) based on normal distribution (population variance σ^2 known and unknown), testing correlation coefficient using Fisher's z transformation, 2.2 One sample and two sample tests for population proportion 2.3 Tests based on t-distribution: a. One sample t-tests for population mean b. Two sample t-tests for equality of population means c. Paired t test d. Test of correlation coefficient e. Test of regression coefficient 2.4 Test of equality of two population variances based on F distribution: when i) means are known, ii) means are unknown 2.5 Confidence intervals for population mean and difference of two population means	**16**
III	Tests based on chi-square distribution: a) Test for independence of two attributes arranged in $r \times s$ contingency table. b) Test for 'Goodness of Fit'. c) Test of significance of population variance i) mean is known, ii) mean is unknown.	**6**
IV	Non-parametric tests: a) Sign test b) Wilcoxon's signed rank test c) Run test	**6**

References:

1. Goon A. M., Gupta, M. K. and Dasgupta, B. (1986), *Fundamentals of Statistics, Vol. 2*, World Press, Kolkata.
2. Gupta, S. C. and Kapoor, V. K. (2002), *Fundamentals of Mathematical Statistics*, (*Eleventh Edition*), Sultan Chand and Sons, 23, Daryaganj, New Delhi , 110002 .
3. Gupta, S. C. and Kapoor V. K. (2007), *Fundamentals of Applied Statistics* (*Fourth Edition*), Sultan Chand and Sons, New Delhi.
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8. Mood, A. M., Graybill F. A. and Bose, F. A. (1974), *Introduction to Theory of Statistics (Third Edition, Chapters II, IV, V, VI*), McGraw - Hill Series G A 276
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11. Walpole R. E., Myers R. H. and Myers S. L. (1985), *Probability and Statistics for Engineers and Scientists (Third Edition, Chapters 4, 5, 6, 8, 10)*, Macmillan Publishing Co. Inc. 866, Third Avenue, New York 10022.
12. Weiss N., *Introductory Statistics*, Pearson education publishers.

S.Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Statistics Practical-IV (STS2403)**	**Number of Credits : 02**

Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Recall the commands of R software.
CO2	Understand the procedure of point estimation and non-parametric tests.
CO3	Compute probabilities of events based on different probability distributions using command of R-software.
CO4	Analyze practical situations using statistical tests for various population parameters.
CO5	Test the goodness of fit for the distributions fitted to practical situations.
CO6	Construct confidence intervals for population parameters.

Sr. No.	Title of the experiment
1.	Obtaining estimator for parameter of the given distribution and checking its properties
2.	Test for means based on normal distribution
3.	Test for proportions based on normal distribution
4.	Test based on t Distribution-I
5.	Test based on t distribution-II
6.	Tests based on chi-square distribution (Independence of attributes)
7.	Tests based on chi-square distribution (Goodness of fit test, test of variance for $H_0 : \sigma^2 = \sigma_0^2$)
8.	Tests based on F distribution (Test for equality of variances)
9.	Construction of confidence interval
10	Computing of probabilities of χ^2, t and F distributions
11	Tests of hypothesis using R – software.
12.	Non-parametric tests