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

S.Y. B.Sc. Semester III

Statistics Paper -1 (STS2301): Sampling Techniques

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

CO1 get basic knowledge of complete enumeration and sample, sampling frame, sampling distribution, sampling and non-sampling errors, principal steps in sample surveys, limitations of sampling etc.,

CO2 get introduction of various statistical sampling schemes such as simple, stratified, systematic and probability proportional to size (pps) sampling,

CO3 get an an idea of conducting the sample surveys and selecting appropriate sampling techniques,

CO4 get knowledge about comparing various sampling techniques.

Unit 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.	**(06L)**
Unit 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 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	**(12L)**

	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.	
Unit 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.	**(12L)**
Unit 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. .	**(6L)**

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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.

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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.

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S.Y. B.Sc. Semester III

Statistics Paper -2 (STS2302): Probability Theory and Distributions – II

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

CO1 get knowledge about continuous random variables and their characteristics such as expectation, variance and higher order moments etc.,

CO2 get ability to handle transformed random variables and derive associated distributions,

CO3 get knowledge of important continuous distributions such as Uniform, Normal, Exponential and relations with some other distributions, fitting of these distributions to real life situations, model sampling,

CO4 get ability to use and interpret Normal probability and q-q plots for testing Normality of data.

Unit I		**Continuous univariate probability distributions:**	**(13 L)**
	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, quartiles	
	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)	

Unit II		Standard Continuous Probability Distributions:	(13L)
	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 : $X \sim U[a, b]$	
		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.) $f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp(\frac{-1}{2\sigma^2}(x-\mu)^2)$, $-\infty < x < \infty$, $-\infty < \mu < \infty$; $\sigma > 0$ 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	
Unit III		Continuous Bivariate Probability distributions:	(10L)
	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. $U = \phi_1 (X ,Y) , V = \phi_2 (X ,Y)$	

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Reference :

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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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
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11. Weiss N., *Introductory Statistics*, Pearson education publishers.

S.Y. B.Sc. Semester III

Statistics Paper -3 (STS2303): Statistics Practical-III

[Credits-2]

Course Outcomes

This course is based on **STS2301**, **STS2302 .**
At the end of this course, students will be able to

CO1 fit various continuous distributions, to draw model samples

CO2 apply appropriate sampling techniques in various real life situations

CO3 compute probabilities using R-software

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

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From Academic Year

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S.Y. B.Sc. Semester IV

Statistics Paper -1 (STS2401): Sampling Distributions

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

CO1 get basic knowledge of derived distributions Chi-square, Student's t and Snedecor's F distributions and their interrelations

CO2 understand and apply basic concepts on sampling distributions

Unit 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's normal approximation (without proof) 1.3 Distribution of $\frac{X}{X+Y}$ and $\frac{X}{Y}$ where X and Y are two independent chi- square random variables	(10L)
Unit 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	(08L)

	such that U ~ N(0, 1) , V ~ χ^2_n 2.2 Derivation of p.d.f., nature of probability curve, mean, variance, moments, mode, use of tables of t-distribution for calculation of probabilities, statement of normal approximation	
Unit 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	(9L)
Unit IV	**Sampling Distributions:** 4.1 Random sample from a distribution of r.v. X as i. i. d. r. v.s. $X_1, X_2, ..., X_n$ 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	(09L)

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Reference :

1. Goon A. M., Gupta, M. K. and Dasgupta, B. (1986), *Fundamentals of Statistics, Vol. 2*, World Press, Kolkata.
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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.

S.Y. B.Sc. Semester IV

Statistics Paper -2 (STS2402): Statistical Methods – II

[Credits-2]

Course Outcomes At the end of this course, students will be able to	
CO1	apply theory of point estimation and testing of hypotheses,
CO2	Understand tests for means, proportions, and correlation coefficient based on normal distribution,
CO3	apply tests for means, correlation coefficient and regression coefficient based on t distribution,
CO4	apply Chi-square, F tests, non-parametric tests

Unit 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 hypothesis, critical region, type I error, type II error, power of the test, level of significance, p-value.	(08L)
Unit 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	(16L)

	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	
Unit 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.	(6L)
Unit IV	Non-parametric tests: a) Sign test b) Wilcoxon's signed rank test c) Run test	(6L)
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Reference :

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 .
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S.Y. B.Sc. Semester III

Statistics Paper -3 (STS2403): Statistics Practical-IV

[Credits-2]

Course Outcomes

This course is based on **STS2401**, **STS2402 .**

At the end of this course, students will be able to

CO1 study application of small sample and large sample tests, confidence interval estimation , nonparametric tests to real life problems,

CO2 carry out the tests using R-software

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