Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar (Autonomous)

(Affiliated to Savitribai Phule Pune University, Pune)

Choice Based Credit System (CBCS)

Framework for Syllabus

Bachelor of Science (B. Sc.) Statistics

Implemented from

Academic year 2022 -23

F.Y. B. Sc.(Statistics)

Semester - I

Course Type	Course Code	Course Title	Credits
DSCC A - 1	BSC-ST 101 T	Descriptive Statistics-I Using MS-Excel	02
DSCC A - 2	BSC-ST 102 T	Introduction to Probability	02
DSCC A -3 Practical	BSC-ST 103 P	Practical (Based on MS-Excel)-I	1.5

Semester - II

Course Type	Course Code	Course Title	Credits
DSCC A-4	BSC-ST 201 T	Descriptive Statistics-II Using R	02
DSCC A-5	BSC-ST 202 T	Discrete Probability Distributions	02
DSCC A-6 Practical	BSC-ST 203 P	Practical (Based on R) - II	1.5

S.Y. B. Sc. (Statistics)

Semester -III

Course Type	Course Code	Course Title	Credits
DSCC A-7	BSC-ST 301 T	Bivariate Discrete Probability Distributions	02
DSCC A-8	BSC-ST 302 T	Continuous Probability Distributions	02
DSCC A-9 Practical	BSC-ST 303 P	Practical (Based on R) - III	02

Semester - IV

Course Type	Course Code	Course Title	Credits
DSCC A-10	BSC-ST 401 T	Sampling Distributions	02
DSCC A-11	BSC-ST 402 T	Large and Small Sample Statistical tests using R	02
DSCC A-12 Practical	BSC-ST 403 P	Practical (Based on R) - IV	02

T.Y. B. Sc.
(Statistics)
Semester -V

Course Type	Course Code	Course Title	Credits
DSCC A-1	BSC-ST 501 T	Probability Distributions	02
DSCC A-2	BSC-ST 502 T	Theory of Estimation	02
DSCC A-3	BSC-ST 503 T	Sampling Theory and Methods	02
DSCC A-4	BSC-ST 504 T	Design of Experiment Using SPSS	02
DSCC A-5	BSC-ST 505 T	Regression Analysis Using SPSS	02
DSCC A-6	BSC-ST 506 T	Linear Algebra Using R	02
DSCC A-7 Practical	BSC-ST 507 P	Practical-V (Based on BSC-ST-501 T and BSC-ST-502 T)	02
DSCC A-8 Practical	BSC-ST 508 P	Practical-VI (Based on BSC-ST-503 T and BSC-ST-504T)	02
DSCC A-9 Practical	BSC-ST 509 P	Practical-VII (Based on BSC-ST-505 and BSC-ST-506)	02
DSEC-A-10	BSC-ST 510 T	Python Programming	02
DSEC-A-11	BSC-ST 511 T	Operations Research Or Statistics In Agriculture	02

Semester -VI

Course Type	Course Code	Course Title	Credits
DSCC A-12	BSC-ST 601 T	Theory of Testing of Hypothesis	02
DSCC A-13	BSC-ST 602 T	Categorical Data Analysis Using SPSS	02
DSCC A-14	BSC-ST 603 T	Introduction to Multivariate Analysis	02
DSCC A-15	BSC-ST 604 T	Reliability Analysis	02
DSCC A-16	BSC-ST 605 T	Time Series Using SPSS	02
DSCC A-17	BSC-ST 606 T	Introduction to Stochastic Process	02
DSCC A-18 Practical	BSC-ST 607 P	Practical-VIII	02

		(Based on BSC-ST-601 T and BSC-ST-602 T)	
DSCC A-19 Practical	BSC-ST 608 P	Practical-IX (Based on BSC-ST-603 T and BSC-ST-604 T)	02
DSCC A-20 Practical	BSC-ST 609 P	Project	02
DSEC-A-21	BSC-ST 610 T	Data Visualization Using Tableau software	02
DSEC-A-22	BSC-ST 611 T	Basics of Data Science	02

Note: The End of Semester (EOS) Examination of following courses will be in online mode.

DSEC-A-10	BSC-ST 510 T	Python Programming	02
DSEC-A-21	BSC-ST 610 T	Data Visualization Using Tableau software	02

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Bachelor of Science (B. Sc.) Statistics

Syllabus of

S. Y. B. Sc. Statistics

Implemented from

Academic year 2022 -23

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar (Autonomous)

Board of Studies in Statistics

Sr. No.	Name	Designation
1	Prof. M. S. Kasture	Chairman
2	Dr. A. A. Kulkarni	Member
3	Dr. A. J. Shivagaje	Member, Nominated by Academic Council
4	Dr. A. K. Khamborkar	Member, Nominated by Academic Council
5	Prof. S. V. Kawale	Member, Nominated by Hon. Vice Chancellor, SPPU, Pune
6	Dr. S. B. Pathare	Alumni Member, Nominated by Hon. Principal
7	Mr. Anirudha Deshmukh	Industry Expert Member, Nominated by Hon. Principal
8	Dr. V. P. Narkhede	Subject Expert, Special Nominated Member by Hon. Principal
9	Prof. S.A. Tarate	Member (Co-opted)
10	Dr. S. D. Jagtap	Member (Co-opted)
11	Dr. N.T. Shelke	Member (Co-opted)
12	Dr. B.P. Thakur	Member (Co-opted)

1. Prologue/ Introduction of the programme: Atleast one page

It is known that in economic activities are of three types, agriculture, industrial and service. In the same way the subject Statistics is a SERVICE SCIENCE having potential to address the problems in these three fields. In research application of Statistics is mandatory. In the present days, apart from traditional field of career, Data Science, Data Analytics, Data Mining, Data Visualization are the upcoming field of career for Statistics students. In these field student must have mathematical ability, statistical thinking, computer (Software and programming) knowledge and communication (Verbal and written). These points are taken into consideration to design the syllabus and examination pattern of Statistics. In addition to academics, the department takes care to arrange a series of lectures on interview skills, preparation of CV, improve communication skill and overall personality development. The students are given the task of event management so that they can practice the principles of management such as leadership, creativity, communication, time management, group activity, team work, etc. In general, through curricular, co-curricular and extra-curricular activities student in three years is developed as thought provoker, problem solver, technologically sound, with command on communication, strong self-confidence.

B. Sc. in Statistics program is of three years' duration, with semester pattern for all the three years. The important feature of the syllabus is that, all practical's form first year to third year will be conducted on computer using MS-EXCEL/ R Suit, Python programming and Tableau.

The feature is at the in all courses, end of every chapter, self-learning activities are listed. These self-learning activities will play important role in creating interest in the subject and also boost their confidence. Further group activities will give the chance to explore their creativity and ideas. In addition, the verbal and written communication will be improved. These self-learning activities are expected to motivate students to participate in various student related academic events organized by home college or by other colleges too.

The course on Tableau will give an opportunity to learn thousands of various data presentation types and to present the complex data by easy way. The practical examinations of all courses will be on computer.

In T.Y. B.Sc. examination of one theory course at each semester will be on computer. In short, maximum exposure is given to students to work on computer and evaluate them on computer.

The syllabus is framed with appropriate weightage of theory, applied and skill enhancement courses. After receiving B.Sc. degree, student is expected to have minimum knowledge of various courses and student will have ability to analyze the data with relevant interpretation of results.

2. **Programme outcomes (PoS)**

Students enrolled in the program complete a curriculum that exposes and trains students in a full range of essential skills and abilities. They will have the opportunity to master the following objectives.

a) Student will achieve the skill of understanding the data.
b) Student will be able to develop the data collection instrument.
c) Student will have skill to write a story using data visualization.
d) Student will understand the interdisciplinary approach to correlate the statistical concepts with concepts in other subjects.
e) Student will be made aware of history of Statistics and hence of its past, present and future role as part of our culture.
f) Students will demonstrate conceptual domain knowledge of the Statistics in an integrated manner.
g) Student will play the key role in management for effective functioning of MIS.

I. Programme Structure and Course Titles

Sr. No.	Class	Semester	Course Code	Course Title	Credits
1.	F.Y. B.Sc.	I	BSC-ST 101 T	Descriptive Statistics -I Using MS-Excel	02
2.	F.Y. B.Sc.	I	BSC-ST 102 T	Introduction to Probability	02
3.	F.Y. B.Sc.	I	BSC-ST103 P	Practical (Based on MS-Excel)-I	1.5
4.	F.Y. B.Sc.	II	BSC-ST 201 T	Descriptive Statistics-II Using R	02
5.	F.Y. B.Sc.	II	BSC-ST 202 T	Discrete Probability Distributions	02
6.	F.Y. B.Sc.	II	BSC-ST 203 P	Practical (Based on R) - II	1.5
7.	S.Y. B.Sc.	III	BSC-ST 301 T	Bivariate Discrete Probability Distributions	02
8.	S.Y. B.Sc.	III	BSC-ST 302 T	Continuous Probability Distributions	02
9.	S.Y. B.Sc.	III	BSC-ST 303 P	Practical (Based on R) - III	02
10.	S.Y. B.Sc.	IV	BSC-ST 401 T	Sampling Distributions	02
11.	S.Y. B.Sc.	IV	BSC-ST 402 T	Large and Small Sample Statistical tests using R	02
12.	S.Y. B.Sc.	IV	BSC-ST 403 P	Practical (Based on R) - IV	02
13.	T.Y. B.Sc.	V	BSC-ST 501 T	Probability Distributions	02
14.	T.Y. B.Sc.	V	BSC-ST 502 T	Theory of Estimation	02
15.	T.Y. B.Sc.	V	BSC-ST 503 T	Sampling Theory and Methods	02
16.	T.Y. B.Sc.	V	BSC-ST 504 T	Design of Experiment Using SPSS	02
17.	T.Y. B.Sc.	V	BSC-ST 505 T	Regression Analysis Using SPSS	02
18.	T.Y. B.Sc.	V	BSC-ST 506 T	Linear Algebra Using R	02
19.	T.Y. B.Sc.	V	BSC-ST 507 P	Practical-V (Based on BSC-ST-501 T and BSC-ST-502 T)	02
20.	T.Y. B.Sc.	V	BSC-ST 508 P	Practical-VI (Based on BSC-ST-503 T and BSC-ST-504T)	02

21.	T.Y. B.Sc.	V	BSC-ST 509 P	Practical-VII (Based on BSC-ST-505 and BSC-ST-506)	02
22.	T.Y. B.Sc.	V	BSC-ST 510 T	Python Programming	02
23.	T.Y. B.Sc.	V	BSC-ST 511 T	Operations Research Or Statistics In Agriculture	02
24.	T.Y. B.Sc.	VI	BSC-ST 601 T	Theory of Testing of Hypothesis	02
25.	T.Y. B.Sc.	VI	BSC-ST 602 T	Categorical Data Analysis Using SPSS	02
26.	T.Y. B.Sc.	VI	BSC-ST 603 T	Introduction to Multivariate Analysis	02
27.	T.Y. B.Sc.	VI	BSC-ST 604 T	Reliability Analysis	02
28.	T.Y. B.Sc.	VI	BSC-ST 605 T	Time Series Using SPSS	02
29.	T.Y. B.Sc.	VI	BSC-ST 606 T	Introduction to Stochastic Process	02
30.	T.Y. B.Sc.	VI	BSC-ST 607 P	Practical-VIII (Based on BSC-ST-601 T and BSC-ST-602 T)	02
31.	T.Y. B.Sc.	VI	BSC-ST 608 P	Practical-IX (Based on BSC-ST-603 T and BSC-ST-604 T)	02
32.	T.Y. B.Sc.	VI	BSC-ST 609 P	Project	02
33.	T.Y. B.Sc.	VI	BSC-ST 610 T	Data Visualization Using Tableau software	02
34.	T.Y. B.Sc.	VI	BSC-ST 611 T	Basics of Data Science	02

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New Arts, Commerce and Science College, Ahmednagar (Autonomous)
Syllabus of S. Y. B. Sc. Statistics
under
Faculty of Science

Semester – III	**Paper – I**
Course Code: BSC-ST 301 T	**Title of the Course: Discrete Bivariate Probability Distributions**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

a. On completion of this course students will get in depth knowledge of general concepts of bivariate probability distributions.
b. Students will get sound knowledge of a probability distributions with lot of applications in industrial field.
c. Students will get the complete idea about bivariate probability distributions that helps the comparison and to draw the inference.
d. Practicing learning of different concepts in this course using R coding will improve their logical thinking.

Detailed Syllabus:

Unit-I		General Concepts in Discrete Bivariate Probability Distributions	09
	1.1	Discrete bivariate random vector or variable (X, Y): Joint p. m. f., joint c. d. f, properties, probabilities of events related to random variables Marginal and conditional distributions. Plot p.d.f. and c.d.f. of some non-standard probability distributions using R code.	
	1.2	Expectation of r.v. (X, Y), 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] & E{E[Y|X=x]} = E[Y], regression as a conditional expectation. Theorems on expectation: i) E(X+Y) = E(X) + E(Y) & E(aX+ bY+ c) ii) Var(aX+ bY+ c) Independence of random variables X and Y and also its extension to k random variables. E(XY) = E(X)*E(Y) if X and Y are independent, generalization to k variables	

	1.3	Moment Generating Function (MGF): $M_{X,Y}(t_1, t_2)$, properties, MGF of marginal distribution of random variables(r.v.s.), 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. Probability Generating Function (PGF) Cumulant Generating Function (CGF).	
		Self-Learning Activity: i) Use PPT to visualize the p.m.f. and c.d.f. ii) Write a summary of five webpages on M.G.F. iii) Write a summary of three video on C.G.F.	
Unit-II		Bivariate Binomial Distribution (Trinomial Distribution)	06
	2.1	Trinomial Theorem (Proof by i) Principal of induction, ii) repetitive use of binomial Expansion), number of terms in Trinomial expansion. Joint PMF of Bivariate Binomial with parameters (n, p1, p2) P(X1, X2)= $\frac{n!}{X_1!\, X_2!(n-X_1-X_2)!}\, {p_1}^{x_1}{p_2}^{x_2}(1-p_1-p_2)^{(n-x_1-x_2)}$ with appropriate range. Notation: (X1, X2) ~ B_2 (n, p1, p2)	
	2.2	MGF, PGF and CGF of Bivariate Binomial, Moment from MGF and CGF, Variance-Covariance Matrix, Correlation matrix.	
	2.3	Marginal distribution, conditional distribution, Conditional mean and conditional variance, Additive property, Distribution of X1+X2, Applications and numerical examples. R coding to plot jpmf for different combination of parameters. R coding to plot the distribution under additive property. R coding to compute probabilities of various events.	
		Self-Learning Activity: 1. Prepare PPT presentation/ R coding to visualize p.m.f. and c.d.f. of Bivariate Binomial Distribution.	

		2. Prepare PPT presentation/ R coding to visualize p.m.f. and c.d.f. of transformation of Bivariate Binomial Distribution. 3. Write a summary on videos of applications Bivariate Binomial Distribution. 4. State at least five illustrations of Bivariate Binomial Distribution 5. Prepare PPT presentation on moments of Bivariate Binomial Distribution. 6. R code to draw model sample from Bivariate Binomial Distribution.	
Unit-III		Bivariate Poisson Distribution	06
	3.1	Bivariate Poisson random variable: If Y1, Y2 and Y3 are independent Poisson random variable with parameters $\theta_1, \theta_2, and\ \theta_{12}$ respectively. Let X1 = Y1+Y3 and X2=Y2+Y3 then (X1, X2) is Bivariate Poisson random variable and has Bivariate Poisson Distribution with parameters $(\theta_1, \theta_2, \theta_{12}) \in R^{3+}$ Statement and Derivation of Joint PMF of Bivariate Poisson Distribution: $P(x1,x2) = e^{-(\theta_1+\theta_2+\theta_{12})} \sum_{i=0}^{\min(x1,,x2)} \frac{\theta_1{}^{x1-i}\ \theta_2{}^{x2-i}\ \theta_{12}{}^{i}}{(x2-i)!(x2-i)!i1!}$, With appropriate Range Interpretation of Parameters. Notation: (X1, X2) ~ BVP($\theta_1, \theta_2, \theta_{12}$) Marginal Distributions, Expectations, Variances	
	3.2	Joint MGF, Joint PGF and Joint CGF, Raw moments using MGF, central moments using CGF	
	3.3	Covariance, Variance-Covariance Matrix correlation matrix, Conditional Distribution, Conditional mean and conditional variance. Applications and numerical examples.	
	3.4	R coding to plot jpmf for different combination of parameters. R coding to compute probabilities of various events.	
Unit-IV		Bivariate Negative Binomial Distribution	09
	4.1	Joint PMF: $p(x1,x2) = \frac{\Gamma(x1+x2+k)}{x_1!x_2!\Gamma k} p_1^{x_1} p_2^{x_2} (1-p_1-p_2)^k$	

		with appropriate Range. Marginal Distribution, Expectation, Variance, Conditional Distributions. Joint MGF, Joint PGF, Joint CGF. Moments using MGF and CGF, Covariance, Correlation Coefficient, Conditional Distribution, Conditional Expectation.	
	4.2	Symmetric Bivariate Negative Binomial Distribution: Joint Probability Mass function: $p(x_1, x_2) = (\frac{\theta}{\theta + 2\phi})^{\theta} \frac{(\theta - 1 + x_1 + x_2)!}{(\theta - 1)! x_1! x_2!} (\frac{\phi}{\theta + 2\phi})^{x_1 + x_2}$ With appropriate range. Joint MGF, Joint PGF, Joint CGF, marginal distributions, Expectation, Variance, Moments using MGF and CGF. Covariance, Correlation Coefficient, Conditional Distribution, Conditional Expectation	
	4.3	R coding to plot jpmf for different combination of parameters of distribution in 4.1 and 4.2. R coding to compute probabilities of various events of distribution in 4.1 and 4.2.	
		Self-Learning Activity: 1. Prepare PPT presentation/ R coding to visualize p.m.f. and c.d.f. of Bivariate Negative Binomial Distribution 2. Write a summary on videos of applications Bivariate Negative Binomial Distribution 3. State at least five illustrations of Bivariate Negative Binomial Distribution 4. R code to draw model sample from Bivariate Negative Binomial Distribution.	

Suggested Readings:

1. Fundamentals of Mathematical Statistics, by Gupta and V.K. Kapoor.
2. Discrete Multivariate Distributions, by Norman L. Johnson, Samuel Kotz and N. Balakrishnan.

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Syllabus of S. Y. B. Sc. Statistics
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Faculty of Science

Semester – III	**Paper – II**
Course Code: BSC-ST 302 T	**Title of the Course: Continuous Probability Distributions**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

a. On completion of this course students will get in depth knowledge of general concepts of univariate and bivariate probability distributions.
b. Students will get sound knowledge of a probability distributions with lot of applications in industrial field.
c. Students will get the complete idea about probability distributions that helps the comparison and to draw the inference.
d. Practice of learning of different concepts in this course using R coding will improve their logical thinking.

Detailed Syllabus:

Unit-I		General Concepts in Continuous Univariate Distributions	09
	1.1	Continuous sample space: Definition, illustrations. Continuous random variable: Definition, probability density function (p.d.f.), cumulative distribution function (c.d.f.), properties of c.d.f., and probabilities of events related to random variable. Plot p.d.f. and c.d.f. of some non-standard probability distributions using R code.	
	1.2	Expectation of continuous r.v., expectation of function of r.v., E [g(X)], mean, variance, geometric mean, harmonic mean, median, mode, Partition values: Quartiles (Q_1, Q_2, Q_3), Deciles, Percentiles. Raw and central moments, skewness, kurtosis, mean deviation about constant, about mean, about median, about mode.	
	1.3	Moment Generating Function (M.G.F.): Definition, Properties, Deriving the first four raw moments from MGF. Cumulant Generating Function(C.G.F.) : Definition, Properties, deriving the first four central moments from CGF.	

	1.4	Probability distribution of function of r.v. Y=g(X) using i) Jacobian of transformation for g(.) monotonic function and one-to-one, on to function, ii) Distribution function for $Y= X^2$, Y= |X| etc. iii) M.G.F. of g(X).	
		Self-Learning Activity: 1. Prepare PPT presentation to visualize the p.d.f. and c.d.f. 2. Prepare PPT presentation on M.G.F. 3. Prepare PPT presentation on C.G.F.	
Unit-II		Standard Continuous Univariate Distributions:	06
	2.1	Uniform or Rectangular Distribution	
		Probability density function (p.d.f.) $f(x) = \begin{cases} \frac{1}{(b-a)}, & a \le x \le b \\ 0, & Otherwise \end{cases}$ Notation: X→ U [a, b] p. d. f., sketch of p. d. f. & c. d. f., mean, median, mode, variance, standard deviation, C.V., symmetry, M.G.F. and C.G.F., first four raw moments based on M.G.F. and four central moments based on C.G.F., quartiles, deciles and percentiles. Measures of skewness and kurtosis based on moments and quartiles. Distributions of i) $\frac{X-a}{b-a}$, ii) $\frac{b-X}{b-a}$, iii) Y= F(X), where F(X) is the c. d. f. of continuous r. v. X. Model sampling from Uniform distribution. Distributions of X+Y, X-Y Plot p.d.f. and c.d.f. of Uniform distribution using R code. R code for quartiles, deciles and percentiles. R code to draw model random sample.	
		Self-Learning Activity: 1. Prepare PPT presentation/ R coding to visualize p.d.f. and c.d.f. of Uniform Distribution. 2. Prepare PPT presentation/ R coding to visualize p.d.f. and c.d.f. of transformation of Uniform Distribution. 3. Write a summary on videos of applications of Uniform Distribution. 4. State at least five illustrations of Uniform Distribution. 5. Prepare PPT presentation on moments of Uniform Distribution. 6. Prepare PPT presentation/ R coding on quartiles, deciles and percentiles of Uniform Distribution.	

		7. Prepare PPT presentation/ R coding on skewness and kurtosis of Uniform Distribution.	
	2.2	Exponential Distribution	
		Probability density function (p. d. f.) $$f(x) = \begin{cases} \alpha e^{-\alpha x}, & x \geq 0, \alpha > 0 \\ 0, & Otherwise \end{cases}$$ Notation: X~ Exp(α) Nature of density curve, interpretation of α as a interarrival rate of customer's joining the queue and $\frac{1}{\alpha}$ as mean, mean, median, mode, variance, standard deviation, C.V., M.G.F., C.G.F., moments based on M.G.F., C.G.F., skewness, kurtosis, c.d.f., graph of c.d.f., lack of memory or forgetfulness property, quartiles, deciles, percentiles, mean deviation about mean, Additive property. Distribution of min (X, Y) and max (X, Y) with X, Y i.i.d. exponential random variables. Plot p.d.f. and c.d.f. of Exponential distribution using R code. R code for quartiles, deciles and percentiles. R code to draw model random sample.	
		Self-Learning Activity: 1. Prepare PPT presentation/ R coding to visualize p.d.f. and c.d.f. of Exponential Distribution. 2. Prepare PPT presentation/ R coding to visualize p.d.f. and c.d.f. of transformation of Exponential Distribution. 3. Write a summary on videos of applications Exponential Distribution. 4. State at least five illustrations of Exponential Distribution. 5. Prepare PPT presentation on moments of Exponential Distribution. 6. Prepare PPT presentation/ R coding on quartiles, deciles and percentiles of Exponential Distribution. 7. Prepare PPT presentation/ R coding on skewness and kurtosis of Exponential Distribution. 8. Verify forgetfulness property using R code.	
Unit-III		Gamma Distribution:	06
	3.1	Probability density function (p. d. f.) $$f(x) = \frac{\alpha^{\lambda}}{\Gamma\lambda} e^{-\alpha x} x^{\lambda-1}, \quad x \geq 0, \alpha > 0, \lambda > 0$$ $$= 0 \quad , \text{Otherwise}$$	

		Notation: X~ G (α, λ) Nature of density curve, mean, median, mode, variance, standard deviation, C.V., special cases (i) α = 1, (ii) λ = 1, M.G.F., C.G.F., moments based on M.G.F. and C.G.F., cumulants, Measures of skewness and kurtosis based on moments, Additive property. Distribution of sum of n i.i.d. exponential variables. Relation between distribution function of Poisson and gamma variates, Recurrence relation between moments. Plot p.d.f. and c.d.f. of Uniform distribution using R code. R code for quartiles, deciles and percentiles. R code to draw model random sample.	
		Self-Learning Activity: 1. Prepare PPT presentation/ R coding to visualize p.d.f. and c.d.f. of Gamma Distribution. 2. Prepare PPT presentation/ R coding to visualize p.d.f. and c.d.f. of transformation of Gamma Distribution. 3. Write a summary on videos of applications Gamma Distribution. 4. State at least five illustrations of Gamma Distribution. 5. Prepare PPT presentation on moments of Gamma Distribution. 6. Prepare PPT presentation/ R coding on quartiles, deciles and percentiles of Gamma Distribution. 7. Prepare PPT presentation/ R coding on skewness and kurtosis of Gamma Distribution. 8. R code to draw model sample from Gamma distribution. 9. Use R code to verify relation between distribution function of Poisson and Gamma variates.	
Unit-IV		Normal or Gaussian Distribution	09
	4.1	Probability density function (p. d. f.) $$f(x) = \begin{cases} \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}(\frac{x-\mu}{\sigma})^2}, & -\infty < X, \mu < \infty, \sigma > 0 \\ 0, & Otherwise \end{cases}$$ Notation: X~ N (μ, σ^2) P. d. f. curve, identification of scale and location parameters, nature of probability curve, mean, median, mode, variance, standard deviation, C.V., M.G.F., C.G.F., central moments, cumulants, skewness, kurtosis, quartiles, deciles, percentiles, points of inflexion of probability curve, mean deviation, additive property, probability distribution of : i) $(\frac{x-\mu}{\sigma})$ Standard Normal Variable (SNV), ii) aX+b, iii) aX+bY+c where X and Y are	

		independent normal variates. Probability distribution of $\bar{X}$, the mean of n i.i.d. N(μ,σ^2) r. v s., computations of normal probabilities using R. Central Limit Theorem (CLT) for r.v.s. with finite variance (statement only), its illustration for Poisson and Binomial distributions. Box-Muller transformation and normal probability plot. Plot p.d.f. and c.d.f. of Exponential distribution using R code. R code for quartiles, deciles and percentiles. Draw random sample of size n from Normal distribution using R code.	
		Self-Learning Activity: Write a summary of five web pages on Normal Distribution. 1. Write summary on videos on Normal Distribution. 2. Write summary on applications of Normal Distribution. 3. Write Excel and R commands for Normal Distribution. 4. Prepare PPT presentation on applications of Central Limit Theorem (CLT). 5. Write R code to plot Normal Distribution and show various quantiles, deciles and percentiles. 6. Write R code to study Poisson approximation to Normal distribution. 7. Write R code to study Binomial approximation to Normal distribution.	

Suggested Readings:

1. Fundamentals of Mathematical Statistics, by Gupta and V.K. Kapoor.
2. Continuous Univariate Distributions – 1, by Norman L. Johnson and Samuel Kotz

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Faculty of Science

Semester – III	**Paper – III**
Course Code: BSC-ST 303 P	**Title of the Course: Practical (Based on R) - III**
Credits: 02	**Total Lectures: 60 Hrs.**

Note: All practicals shall be conducted using R coding.

Sr. No.	Title of the Practical	No. of Practical's
1	Applications of Uniform & Exponential Distribution and Plots of distributions.	1
2	Model sampling from Exponential distribution & Normal Distribution using (i) Box-Muller Transformation and (ii) Distribution Function.	1
3	Fitting of Normal distribution and computation of expected frequencies.	1
4	Applications of Normal distribution and Plots of distributions.	1
5	Applications of Gamma distribution and Plots of distributions.	1
6	Applications of Discrete Bivariate Distribution and Plots of JPMF and marginal.	1
7	Fitting of Bivariate Binomial Distribution	1
8	Applications of Bivariate Binomial Distribution and Plots of JPMF and marginal.	1
9	Fitting of Bivariate Poisson Distribution.	1
10	Applications of Bivariate Poisson Distribution and Plots of JPMF and marginal.	1
11	Fitting of Bivariate Negative Binomial Distribution.	1
12	Applications of Bivariate Negative Binomial distribution & Plots of JPMF and marginal.	1
13	Short project equivalent to THREE practical's in a group of size 4 to 5 students	1

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Semester – IV	**Paper – I**
Course Code: BSC-ST 401 T	**Title of the Course: Exact Sampling Distributions**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

a. On completion of this course students will get in depth knowledge of theoretical background of exact statistical tests.
b. Students will understand the basic difference between various sampling distributions.
c. Students will understand the difference between probability distributions and sampling distributions.

Detailed Syllabus:

Unit - I		**Chi-Square (χ^2_n) Distribution**	**09**
	1.1.	Concept of Degrees of Freedom. Definition and derivation Chi-Square distribution as a square of Standard Normal Variate (SNV). Definition and derivation of pdf of Chi Square distribution with n degrees of freedom as a sum of squares of i.i.d. SNV (using MGF and Mathematical Induction). R coding to plot density curve of Chi-Square distribution for various degrees of freedom.	
	1.2	Mean, mode and variance of Chi-Square distribution. MGF, raw moments using MGF, CGF, central moments using CGF, Coefficients of skewness and kurtosis using moments. For given degrees of freedom R code to obtain quantiles of Chi-Square distribution. Additive property of Chi-Square distributions. Computations of various probabilities using R.	
	1.3	Normal approximation to Chi-Square distribution. Joint Distribution of $\bar{X}$ and $\frac{nS^2}{\sigma^2} = \frac{1}{\sigma^2}\sum_{i=1}^{n}(xi - \bar{x})^2$for a random sample from a normal distribution. Independence of $\bar{X}$ and S^2 using orthogonal transformation.	

	1.4	Real life applications of Chi-Square distribution, examples and problems. Use of rchisq, pchisq, dchisq, qchisq and other R commands.	
		Self-Learning Activity: 1. Write a summary of five web pages on Chi- Square Distribution. 2. Write summary on videos on Chi- Square Distribution 3. Write Excel and R commands for Chi- Square Distribution 4. Write R code to plot Chi- Square Distribution and show various quantiles, deciles and percentiles.	
Unit - II		**Student's t-distribution - (t_n)**	**06**
	2.1	Definition and derivation of Student's 't' distribution with 'n' degrees of freedom. R coding to plot density curve of t distribution for various degrees of freedom. R code to compare graphically the density curve of SNV and 't' distribution with various degrees of freedom.	
	2.2	Mean, mode, median and variance of 't' distribution. MGF and CGF of 't' distribution. Raw and central moments and coefficient of Skewness and Kurtosis of 't' distribution. Properties of central moments. Recurrence relation between moments of 't' distribution. For given degrees of freedom R code to obtain quantiles of 't' distribution. Computations of various probabilities using R. Normal approximation to 't' distribution.	
	2.3	Real life applications of 't' distribution, examples and problems. Use of rt, pt, dt, qt and other R commands.	
		Self-Learning Activity: 1. Write a summary of five web pages on t Distribution. 2. Write summary on videos on t Distribution 3. Write Excel and R commands for t Distribution 4. Write R code to plot t Distribution and show various quantiles, deciles and percentiles.	
Unit-III		**Fishers 't' and 'Z' distribution.**	**06**
	3.1	Definition and derivation of Fishers 't' and 'Z' distribution. R code to plot the density curve of Fishers 't' and 'Z' distribution.	

	3.2	MGF of Fishers 'Z' distribution. Moments of Fishers 'Z' distribution using moments. Mean and variance of Fishers 'Z' distribution.	
	3.3	Fishers 'Z' transformation and applications	
	3.4	Use of R coding for computations involved in 3.1, 3.2 and 3.3	
Unit-IV		**Snedecore's F- distribution ($F_{n1,n2}$)**	**09**
	4.1	Definition and derivation of F distribution. R coding to plot density curve of F distribution for various combinations of degrees of freedoms.	
	4.2	Mean, mode and variance of F distribution. r^{th} raw moment of F distribution. Quartiles of 'F' Distribution. Proof of Property P[X<a] + P[1/X > a] = 1. For given degrees of freedom R code to obtain quantiles of F distribution. Distribution of reciprocal of random variable with F distribution. Computations of various probabilities using R.	
	4.3	Interrelations between Chi-Square, 't' and F distribution. Normal approximation to 'F' distribution.	
	4.4	Real life applications of 'F' distribution, examples and problems. Use of rf, pf, df, qf and other R commands.	
		Self-Learning Activity: 1. Write a summary of five web pages on F Distribution. 2. Write summary on videos on F Distribution 3. Write Excel and R commands for F Distribution 4. Write R code to plot F and show various quantiles, deciles and percentiles.	

Suggested Readings:

1. Fundamentals of Mathematical Statistics, by Gupta and V.K. Kapoor.
2. Continuous Univariate Distributions – 1, by Norman L. Johnson and Samuel Kotz

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Semester – IV	**Paper – II**
Course Code: BSC-ST 402 T	**Title of the Course: Large and Small Sample Statistical Tests Using R**
Credits: 02	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

a. On completion of this course students will get basic idea about statistical approach to confirm the logical claims or guess.
b. This course will give an opportunity of applying statistical tests in various fields.
c. Use of R coding on real life data will improve the programming ability of students.

Detailed Syllabus:

Unit-I		General Concepts of Testing of Hypothesis	06
	1.1	Definition of Random sample, Parameter and Statistic, Sampling distribution of a statistic, standard error of a statistic with illustrations (normal, exponential etc), Concept of testing of hypothesis.	
	1.2	Statistical hypothesis, null and alternative hypothesis, simple and composite hypothesis, one sided and two sided alternative hypotheses, critical region, acceptance region, Type-I & Type-II errors, probability of type I error as a level of significance (α), probability of type II error, power of the test, confidence coefficient, p -value. Testing of hypotheses using i) critical region approach, ii) p-value approach and iii) confidence interval approach. One sided and Two sided confidence intervals.	
		Self-Learning Activity: 1. Prepare the poster of basic concepts in testing of hypothesis. 2. Prepare the poster to illustrate the concept of hypothesis. 3. Prepare the poster to illustrate Type-I, Type-II, L.O.S. and power of the test.	
Unit-II		Large Sample Tests for Mean and Proportion	09
	2.1	Tests for Population Mean(s) i) Ho: $\mu = \mu_0$ against $H_1 : \mu \neq \mu_0$, $H_1 : \mu < \mu_0$, $H_1 : \mu > \mu_0$ (Variance is known)	

		ii) Ho: $\mu_1 = \mu_2$ against $H_1 : \mu_1 \neq \mu_2$, $H_1 : \mu_1 < \mu_2$, $H_1 : \mu_1 > \mu_2$ (Variance is known and equal) iii) Ho: $\mu_1 = \mu_2$ against $H_1 : \mu_1 \neq \mu_2$, $H_1 : \mu_1 < \mu_2$, $H_1 : \mu_1 > \mu_2$ (Variance is known and unequal) iv) Testing of (i), (ii) and (iii) using confidence interval. Illustration of computation of power of the test Use of R for testing the above hypothesis	
	2.2	Tests for Population Proportion(s) (large sample / approximate tests) i) Ho: $P = P_0$ against $H_1 : P \neq P_0$, $H_1 : P < P_0$, $H_1 : P > P_0$ ii) Ho : $P_1 = P_2$ against $H_1 : P_1 \neq P_2$, $H_1 : P_1 < P_2$, $H_1 : P_1 > P_2$ iii) Testing of (i) and (ii) using confidence interval. Illustration of computation of power of the test Use of R for testing the above hypothesis	
		Self-Learning Activity: 1. Prepare PPT presentation of tests for Population means. 2. Prepare PPT presentation of tests for Population proportions. 3. Prepare PPT presentation to illustrate tests for Population means. 4. Prepare PPT presentation to illustrate tests for Population proportions. 5. Write R code for test for Population means and interpret it. 6. Write R code for test for Population proportions and interpret it.	
Unit-III		Small Sample Tests – Based on Chi-Square, F and Normal Distribution	09
	3.1	Tests based on chi-square distribution i) Test for independence of two attributes arranged in 2 X 2 Contingency table (with Yate's correction). ii) Test for independence of two attributes arranged in r X s Contingency table, Mc Nemar's test. iii) Test for goodness of fit. iv) Ho : $\sigma^2 = \sigma_0^2$ against one-sided and two-sided alternatives (known mean, unknown mean). Illustration of computation of power of the test Use of R for testing the above hypothesis	
	3.2	Test based on F – distribution Test for Ho: $\sigma_1^2 = \sigma_2^2$ against $H_1 : \sigma_1^2 \neq \sigma_2^2$, $H_1 : \sigma_1^2 > \sigma_2^2$, $H_1 : \sigma_1^2 < \sigma_2^2$ when μ known, unknown Illustration of computation of power of the test Use of R for testing the above hypothesis	
	3.3	Tests based on Z transformation i) Ho: $\rho = \rho_0$ against $H_1: \rho \neq \rho_0$, $H_1: \rho > \rho_0$, $H_1: \rho < \rho_0$ ii) Ho: $\rho_1 = \rho_2$ against $H_1: \rho_1 \neq \rho_2$, $H_1: \rho_1 > \rho_2$, $H_1: \rho_1 < \rho_2$ Illustration of computation of power of the test Use of R for testing the above hypothesis	
		Self-Learning Activity:	

		1. Prepare PPT presentation of tests for independence of two attributes arranged in 2 X 2 Contingency table. 2. Prepare PPT presentation of tests for independence of two attributes arranged in r X s Contingency table. 3. Prepare PPT presentation of test for goodness of fit. 4. Prepare PPT presentation of test based on F – distribution. 5. Prepare PPT presentation of test based on Z transformation. 6. Prepare PPT presentation to illustrate tests independence of two attributes arranged in 2 X 2 Contingency table. 7. Prepare PPT presentation to illustrate tests independence of two attributes arranged in r X s Contingency table. 8. Prepare PPT presentation to illustrate test for goodness of fit. 9. Prepare PPT presentation to illustrate test based on F – distribution. 10. Prepare PPT presentation to illustrate test based on Z transformation. 11. With suitable data write R code for independence of two attributes arranged in 2 X 2 Contingency table. 12. With suitable data write R code for independence of two attributes arranged in r X s Contingency table. 13. With suitable data write R code for tests based on F – distribution. 14. With suitable data write R code for tests based on Z transformation.	
Unit-IV		Small Sample Tests – Based on t Distribution	06
		Tests based on t – distribution i) Ho: $\mu = \mu_0$ against $H_1 : \mu \neq \mu_0$, $H_1 : \mu < \mu_0$, $H_1 : \mu > \mu_0$ (Variance is known) ii) Ho : $\mu_1 = \mu_2$ against $H_1 : \mu_1 \neq \mu_2$, $H_1 : \mu_1 < \mu_2$, $H_1 : \mu_1 > \mu_2$ (Variance is known and equal) iii) Ho : $\mu_1 = \mu_2$ against $H_1 : \mu_1 \neq \mu_2$, $H_1 : \mu_1 < \mu_2$, $H_1 : \mu_1 > \mu_2$ (Variance is known and unequal) iv) Testing of (i) , (ii) and (iii) using confidence interval. v) Paired t-test for one sided and two sided alternatives vi) Ho: $\rho = 0$ against H_1: $\rho \neq 0$ vii) Ho: $\beta = 0$ against H_1: $\beta \neq 0$, β as a regression coefficient Illustration of computation of power of the test Use of R for testing the above hypothesis	
		Self-Learning Activity: 1. Prepare PPT presentation on tests based on t – distribution. 2. Prepare PPT presentation on illustration of tests based on t – distribution. 3. With suitable data write R code for tests based on t – distribution.	

Suggested Readings:

1. Fundamentals of Mathematical Statistics, by Gupta and V.K. Kapoor.

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Course Code: BSC-ST 403 P	**Title of the Course: Practical (Based on R) - IV**
Credits: 02	**Total Lectures: 60 Hrs.**

Sr. No.	**Title of Practical**	**No. of Practical's**
1	Large Sample Test for means and construction of confidence interval for i) Ho: $\mu = \mu_0$ against $H_1 : \mu \neq \mu_0$, $H_1 : \mu < \mu_0$, $H_1 : \mu > \mu_0$ (Variance is known) ii) Ho: $\mu_1 = \mu_2$ against $H_1 : \mu_1 \neq \mu_2$, $H_1 : \mu_1 < \mu_2$, $H_1 : \mu_1 > \mu_2$ (Variance is known and equal) iii) Ho: $\mu_1 = \mu_2$ against $H_1 : \mu_1 \neq \mu_2$, $H_1 : \mu_1 < \mu_2$, $H_1 : \mu_1 > \mu_2$ (Variance is known and unequal) iv) Construction of CI for tests in (i), (ii) and (iii). v) Visualization of Acceptance region, Critical region and CI	1
2	Large sample Test for proportions and construction of confidence interval for i) $H_0 : P = P_0$ against $H_1 : P \neq P_0$, $H_1 : P < P_0$, $H_1 : P > P_0$ ii) $H_0 : P_1 = P_2$ against $H_1 : P_1 \neq P_2$, $H_1 : P_1 < P_2$, $H_1 : P_1 > P_2$ iii) Construction of CI for tests in (i) and (ii). iv) Visualization of Acceptance region, Critical region and CI	1
3	Tests based on Chi-square Distribution i) Ho: $\sigma^2 = \sigma_0^2$ against one-sided and two-sided alternatives (known mean, unknown mean). ii) Goodness of fit iii) Independence of attributes (r × s contingency table) iv) Construction of CI for tests in (i) and (ii). v) Visualization of Acceptance region, Critical region and CI	1
4	a) Test based on F – distribution Test for Ho: $\sigma_1^2 = \sigma_2^2$ against $H_1 : \sigma_1^2 \neq \sigma_2^2$, $H_1 : \sigma_1^2 > \sigma_2^2$, $H_1 : \sigma_1^2 < \sigma_2^2$ when μ known, unknown b) Tests based on t – distribution i) Ho: $\rho = 0$ against $H_1: \rho \neq 0$ ii) Ho: $\beta = 0$ against $H_1: \beta \neq 0$, β as a regression coefficient c) Tests based on Z transformation i) Ho: $\rho = \rho_0$ against $H_1: \rho \neq \rho_0$, $H_1: \rho > \rho_0$, $H_1: \rho < \rho_0$ ii) Ho: $\rho_1 = \rho_2$ against $H_1: \rho_1 \neq \rho_2$, $H_1: \rho_1 > \rho_2$, $H_1: \rho_1 < \rho_2$	1

5	Tests based on t – distribution i) Ho: $\mu = \mu_0$ against $H_1 : \mu \neq \mu_0$, $H_1 : \mu < \mu_0$, $H_1 : \mu > \mu_0$ (Variance is known) ii) Ho : $\mu_1 = \mu_2$ against $H_1 : \mu_1 \neq \mu_2$, $H_1 : \mu_1 < \mu_2$, $H_1 : \mu_1 > \mu_2$ (Variance is known and equal) iii) Ho : $\mu_1 = \mu_2$ against $H_1 : \mu_1 \neq \mu_2$, $H_1 : \mu_1 < \mu_2$, $H_1 : \mu_1 > \mu_2$ (Variance is known and unequal) iv) Testing of (i), (ii) and (iii) using confidence interval. v) Paired t-test for one sided and two sided alternatives	1
6	Study of random sample from Chi-Square Distribution using definition of Chi-Square Distribution.	1
7	Study of random sample from t Distribution using definition of t Distribution.	1
8	Study of random sample from F Distribution using definition of F Distribution.	1
9	Study of interrelations between Normal, t, F and Chi-Square using random sample	1
10	Study of sampling distribution from $N(\mu, \sigma^2)$	1
11	Study of sampling distribution from Exponential distribution	1
12	Study of sampling distribution from Gamma distribution.	1
13	Short project equivalent to THREE practical's in a group of size 4 to 5 students	1