PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

Name of the Faculty: Science & Technology

Syllabus

B.Sc. Statistics Part-II

(Semester-III and IV)

As per NEP-2020

To be implemented from Academic Year 2025-26

Semester-wise Structure for

B. Sc. Statistics (Honors/Research) Programme

as per NEP-2020

(w.e.f. – June 2025)

B.Sc. Part-II (Semester-III) Statistics						
Course Type	**Course Code**	**Course Title**	**Credits**	**Teaching hours/week**		
				T	**P**	**Total**
Major	**DSC1-3**	Discrete Probability Distributions	**2**	**2**	**--**	**2**
	DSC1-3 (P)	Statistics Practical (Major)-III	**1**	**--**	**2**	**2**
	DSC1-4	Continuous Probability Distributions-I	**2**	**2**	**--**	**2**
	DSC1-4 (P)	Statistics Practical(Major)-IV	**1**	**--**	**2**	**2**
Minor	**DSC2-3**	Introduction to Discrete Probability Distributions	**2**	**2**	**--**	**2**
	DSC2-3 (P)	Statistics Practical(Minor)-I	**1**	**--**	**2**	**2**
	DSC2-4	Introduction to Continuous Probability Distributions	**2**	**2**	**--**	**2**
	DSC2-4 (P)	Statistics Practical(Minor)-II	**1**	**--**	**2**	**2**
OE	**OE-3**	Probability Theory	**2**	**2**	**--**	**2**
VSC	**VSC1**	Practical Related to Major-I	**2**	**--**	**4**	**4**
	VSC2	Practical Related to Minor-I	**2**	**--**	**4**	**4**
B.Sc. Part-II (Semester-IV) Statistics						
Major	**DSC1-5**	Continuous Probability Distributions-II	**2**	**2**	**--**	**2**
	DSC1-5 (P)	Statistics Practical(Major)-V	**1**	**--**	**2**	**2**
	DSC1-6	Statistical Methods	**2**	**2**	**--**	**2**
	DSC1-6 (P)	Statistics Practical(Major)-VI	**1**	**--**	**2**	**2**

Minor	**DSC2-5**	Theory of Testing of Hypotheses	**2**	**2**	**--**	**2**
	DSC2-5 (P)	Statistics Practical(Minor)-III	**1**	**--**	**2**	**2**
	DSC2-6	Applied Statistics	**2**	**2**	**--**	**2**
	DSC2-6 (P)	Statistics Practical(Minor)-IV	**1**	**--**	**2**	**2**
OE	**OE-4**	Applications of Statistics	**2**	**2**	**--**	**2**
VSC	**VSC3**	Practical Related to Major-II	**2**	**--**	**4**	**4**
	VSC4	Practical Related to Minor-II	**2**	**--**	**4**	**4**
Field Project	**FP1**	Field Project	**2**	**--**	**4**	**4**

B. Sc. Part-II (Statistics) Semester-III

Major	DSC1-3	Theory	Discrete Probability Distributions	Credits: 02 Hours: 30

Course Outcomes:

The main objective of this course is to acquaint students with concept of discrete probability distributions. At the end of this course students are expected to be able to

1. Understand the concept of discrete random variable and its p.m.f. and c.d.f.
2. Compute mathematical expectation of random variable,
3. Acquire knowledge of discrete probability distributions,
4. Apply discrete probability distributions in real life situations.
5. Understand bivariate discrete distributions, independence of bivariate r.v.s, mathematical expectation of bivariate discrete distribution

Course Content

Unit-1: **Univariate Probability Distributions and Standard Distributions** **(15 hrs.)**

1.1 Univariate Probability Distribution: (Defined on finite and countable infinite sample space)

Definition of discrete random variables, Probability mass function (p.m.f.) and cumulative distribution function (c.d.f.), a discrete random variable, properties of c.d.f. (statements only), Probability distribution of function of a random variable, Median and Mode of a univariate discrete probability distribution, numerical problems

1.2 Mathematical Expectation (Univariate Random Variable): Definition of expectation of a random variable, expectation of a function of a random variable. Results on expectation: i) $E(c) = c$, where c is a constant. ii) $E(aX+b) = aE(X)+b$, where a and b are constants. Definitions of mean, variance of univariate distributions. Effect of change of origin and scale on mean and variance. Definition of raw and central moments and factorial moments up to order 2. Definition of probability generating function (p.g.f.) of a random variable. Effect of change of origin and scale. Definition of mean and variance by using p.g.f. Simple Examples.

1.3 Some Standard Discrete Probability Distributions:

Bernoulli Distribution: p.m.f., mean, variance, distribution of sum of independent and identically distributing Bernoulli variables.

Discrete Uniform Distribution: p.m.f. mean and variance.

Binomial Distribution: p.m.f.

$$P(x) = {}^{n}C_{x}\, p^{x} q^{n-x} \quad , \; x = 0,1,2,\ldots n \quad 0 \le p \le 1, \quad q = 1-p$$
$$= 0 \qquad , \; otherwise$$

Notation: $X \sim B(n, p)$, recurrence relation for successive probabilities, computation of probabilities of different events. p.g.f. and hence or otherwise mean and variance, Examples.

Hypergeometric Distribution: p.m.f.

$$P(x) = \frac{{}^{M}C_{x}\ {}^{N-M}C_{n-x}}{{}^{N}C_{n}} \quad , x = 0,1,2,\ldots \min(n, M)$$
$$= 0 \quad , \textit{otherwise}$$

Notation: $X \sim H(N, M, n)$, mean and variance of distribution assuming $n \le N - M \le M$. Examples.

Unit-2: Standard Distributions and Bivariate Distributions (15 hrs.)

2.1 Some Standard Discrete Probability Distributions: Definition of discrete random variable (defined on countably infinite sample space)

Poisson Distribution: p. m. f.

$$P(x) = \frac{e^{-\lambda}\lambda^{x}}{x!} \quad , x = 0,1,2\ldots\ldots \ \lambda > 0$$
$$= 0 \quad , \textit{otherwise}$$

Notation: $X \sim P(\lambda)$, Mean, variance, moment generating function (m. g. f.). Recurrence relation for successive Probabilities, Additive property of Poisson distribution. For X and Y independent random variables conditional distribution of X given X+Y = n. Poisson distribution as a limiting case of Binomial distribution (without proof), numerical problems.

Geometric Distribution: p. m. f.

$$P(x) = q^{x} p \quad , x = 0,1,2,3,\ldots.\ 0 < p < 1, \ \ q = 1 - p$$
$$= 0 \quad , \textit{otherwise}$$

Notation: $X \sim G(p)$, Mean, Variance, distribution function, m. g. f., Lack of memory property,

Negative Binomial Distribution: p. m. f.

$$P(x) = \binom{x + k - 1}{k - 1} p^{k}\ q^{x} \quad , x = 0,1,2,3,\ldots.\ \ k > 0$$
$$= 0 \quad , \textit{otherwise}$$

Notation: $X \sim NB(k, p)$, Geometric distribution is a particular case of Negative Binomial distribution, Mean, Variance, m. g. f., Recurrence relation for successive probabilities, numerical problems.

2.2 Bivariate Discrete Distribution: Definition of bivariate discrete random variable (X,Y) on finite support, Joint p.m.f., and c.d.f., Properties of c.d.f.(without proof), computation of probabilities of events in bivariate probability distribution, marginal and conditional probability distribution. Independence of two discrete r.v.s.

2.3 Mathematical Expectation (Bivariate random variable): Definition of expectation of function of r.v. in bivariate distribution. Theorems on expectation: (i) E(X+Y) = E(X) +E(Y) (ii) E(XY) = E(X). E(Y) when X and Y are independent. Expectation and variance of linear combination of two discrete r.v.s. Definition of conditional mean, conditional variance. Covariance and correlation coefficient. Cov(aX+bY, cX+dY). Distinction between uncorrelated and independent variables. Proof of the p.g.f. of sum of two independent r.v. as the product of their p.g.f.s.

Books Recommended

1. Bhat B. R., Srivenkatramana T. and Madhava Rao K. S. (1996): Statistics: A Beginner's Text, Vol. 1, New Age International (P) Ltd.

2. Edward P. J., Ford J. S. and Lin (1974): Probability for Statistical Decision-Making, Prentice Hall.

3. Goon A.M., Gupta M.K., and Dasgupta B.: Fundamentals of Statistics Vol. I and II, World Press, Calcutta.

4. Gupta V.K. & Kapoor S.C. Fundamentals of Mathematical Statistics.- Sultan & Chand.

5. Hogg R. V. and Crag R. G.: Introduction to Mathematical Statistics Ed.4.

6. Hoel P. G. (1971): Introduction to Mathematical Statistics, Asia Publishing House.

7. Kore B. G. and Dixit P. G.: "Elementary Probability Theory", Nirali Prakashan, Pune.

8. Meyer P.L. (1970): Introductory Probability and Statistical Applications, Addision Wesley.

9. Mukhopadhyay P. (2006): Probability. Books and Allied (P) Ltd.

10. Rohatgi V. K. and Saleh A. K. Md. E. (2002): An Introduction to probability and statistics. John wiley & Sons (Asia).

11. Snedecor G.W. and Cochran W. G. (1967): Statistical Methods, Lowa State University Press.

Major	**DSC1-4**	**Theory**	**Continuous Probability Distributions-I**	**Credits: 02** **Hours: 30**

Course Outcomes:

After successful completion of this course, students are expected to:

1. Understand univariate continuous distribution, various measures of continuous r.v.s, and probabilities using its probability density function.
2. Aquire the concept of bivariate continuous distributions, independence of bivariate r.v.s, Mathematical expectation of bivariate continuous distribution
3. Apply transformation of univariate and bivariate continuous random variable.
4. Apply multiple and partial correlation as well as regression for the case of trivariate data.

Course Content

Unit-1: **Continuous Univariate and Bivariate Distributions** **(15 hrs.)**

1.1 Continuous Univariate Distributions: Definition of continuous sample space with illustrations, Definition of continuous random variable (r. v.), probability density function (p. d. f.), cumulative distribution function (c. d. f.) and its properties. Expectation of a r. v., expectation of a function of r. v., mean, median, mode, quartiles, variance, harmonic mean, geometric mean, raw and central moments, problems.

Moments generating function (m. g. f.): definition and properties

(i) Standardization property $M_X(0) = 1$, (ii) Effect of change of origin and scale,

(iii) Uniqueness property of m. g. f., (if exists, statement only).

Generation of raw and central moments.

Cumulant generating function (c. g. f.): definition, relations between cumulants and

central moments (up to order four). Problems.

1.2 Continuous Bivariate Distributions: Definition of bivariate continuous r. v. (X, Y), Joint p. d. f., c. d. f with properties, marginal and conditional distribution, independence of r.v.s, evaluation of probabilities of various regions bounded by straight lines. Expectation of function of r.v.s, mean, variance, covariance, correlation coefficient, conditional expectation, regression as conditional expectation if it is linear function of other variable and conditional variance, proof of:

i) $E(X \pm Y) = E(X) \pm E(Y)$, ii) $E\left[E\left(X/Y\right)\right] = E(X)$

If X and Y are independent r.v.s, then

(i) $E(XY) = E(X)\ E(Y)$,

(ii) $M_{X+Y}(t) = M_x(t) \times M_y(t)$

(iii) $M_{X,Y}(t_1,t_2) = M_x(t_1,0) \times M_y(0,t_2)$,

(iv) $M_{X+Y}(t,t) = M_x(t,0) \times M_y(0,t) = M_{X+Y}(t)$.

Numerical Problems.

1.3 Transformations of a continuous random variable: Transformation of a univariate continuous r. v.: Distribution of Y = g(X), where g is monotonic or non-monotonic function using the following methods:
(i) Jacobian of transformation, (ii) Distribution function and (iii) m.g.f. methods. Transformation of a continuous bivariate r.v.s: Distribution of a bivariate r.v.s using Jacobin of transformation. Problems.

Unit-2: Multiple regression, correlation and partial correlation coefficients (15 hrs.)

2.1 Multiple Linear Regression (for trivariate data only): Concept of multiple linear regression, Plane of regression, Yule's notation, correlation matrix. Fitting of regression plane by method of least squares, definition of partial regression coefficients and their interpretation. Residual: definition, order, properties, derivation of mean and variance, covariance between residuals.

2.2 Multiple and Partial Correlation (for trivariate data only): Concept of multiple correlation. Definition of multiple correlation coefficient Ri.jk, derivation of formula for multiple correlation coefficient. Properties of multiple correlation coefficient:
i) 0 ≤Ri.jk≤1, (ii) Ri.jk>max{|rij|, |rik|, |rij.k|, |rik.j| }
(iii) Ri.jk≥ |rik| i = j =k = 1, 2, 3. i≠j, i≠k. Interpretation of Ri.jk =1, Ri.jk = 0, coefficient of multiple determination $Rij.k$

Concept of partial correlation. Definition of partial correlation coefficient rij.k. Properties of partial correlation coefficient; (i) -1 ≤rij.k≤1, (ii) $bij.k \times bji.k = rij.k$ Numerical problems.

Books Recommended

1. Parimal Mukhopadhyaya: An Introduction to the Theory of Probability. World Scientific Publishing.
2. Hogg R. V. and Craig A.T.: Introduction to Mathematical Statistics (Third edition), Macmillan Publishing, New York.
3. Gupta S. C. & Kapoor V.K.: Fundamentals of Mathematical Statistics. Sultan Chand & sons, New Delhi.
4. Goon, A.M., Gupta M.K. and Dasgupta B: Fundamentals of Statistics Vol. I andVol. II World Press, Calcutta.
5. Dr. Kore B. G. and Dr. Dixit P. G.: "Probability Distributions-I", Nirali Prakashan, Pune.
6. Mood A.M., Graybill F.A.: Introduction to theory of Statistics. (Chapter II, IV, V,VII) and Bose D.C. Tata, McGraw Hill, New Delhi. (Third Edition)
7. Walpole R.E. & Mayer R.H.: Probability & Statistics. (Chapter 4, 5, 6, 8, 10) MacMillan Publishing Co. Inc, New York.

DSC1-3 (P)	**Practical**	**Statistics Practical (Major)-III**	**Credits: 01 Hours: 30**

Course Outcomes:

At the end of this course students are expected to be able to

1. Compute the probabilities of univariate probability distributions.
2. Compute the probabilities of Binomial, Hypergeometric distributions.
3. Compute the probabilities of Poisson, Geometric and Negative Binomial, distributions.
4. Compute the marginal and conditional probabilities and expectations and conditional expectations and variances.

List of Practical's

1	Applications of Univariate Probability Distribution
2	Applications of Binomial Distribution
3	Applications of Hypergeometric Distribution
4	Applications of Poisson Distribution
5	Applications of Geometric and Negative Binomial Distribution
6	Bivariate Discrete Distribution – I (Marginal and Conditional Distribution)
7	Bivariate Discrete Distribution – II (Expectation /conditional expectation / variance / conditional variance /covariance / correlation coefficient)

DSC1-4 (P)	**Practical**	**Statistics Practical (Major)-IV**	**Credits: 01** **Hours: 30**

Course Outcomes:

At the end of this course students are expected to be able to

1. Compute the marginal and conditional distributions of a bivariate continuous random variables.
2. Compute the expectation and conditional expectation, variances, covariance and correlation coefficients of a bivariate continuous random variables.
3. Find the probability distribution of random variables using transformations of univariate and bivariate continuous distribution.
4. Compute the equation of plane of regression of trivariate data.
5. Compute the multiple and partial correlation coefficients.
6. Fit the straight lines, second degree curves and exponential curves.

List of Practical's

1	Bivariate Continuous distribution-I. (Marginal and conditional distribution, computation of probabilities of events).
2	Bivariate Continuous distribution-II (Expectation /conditional expectation / variance / conditional variance /covariance / correlation coefficient)
3	Transformation of univariate and bivariate continuous distribution.
4	Multiple regression
5	Multiple and Partial Correlation coefficient
6	Fitting of straight lines and second degree curves
7	Fitting of curves of type $Y = a\,b^X$, $Y = a\,X^b$ and $Y = a\,e^{bX}$

Minor	**DSC2-3**	**Theory**	**Introduction to Discrete Probability Distributions**	**Credits: 02** **Hours: 30**

Course Outcomes:

The main objective of this course is to acquaint students with concept of random variable and discrete probability distribution. At the end of this course students are expected to be able to

1. Acquire concept of discrete random variable and its p.m.f. and c.d.f.
2. Compute mathematical expectation of random variable,
3. Acquire knowledge of discrete probability distributions,
4. Apply discrete probability distributions in real life situations.
5. Understand bivariate discrete distributions, independence of bivariate r.v.s, Mathematical expectation of bivariate discrete distribution

Course Content

2 Unit-1: Univariate Probability Distributions and Standard Distributions (15 hrs.)

2.1 Univariate Probability Distribution: (Defined on finite and countable infinite sample space)

Definition of discrete random variables, Probability mass function (p.m.f.) and cumulative distribution function (c.d.f.), a discrete random variable, properties of c.d.f. (statements only), Probability distribution of function of a random variable, Median and Mode of a univariate discrete probability distribution, numerical problems

1.2 Mathematical Expectation (Univariate Random Variable): Definition of expectation of a random variable, expectation of a function of a random variable. Results on expectation: i) $E(c) = c,$ where c is a constant. ii) $E(aX + b) = aE(X) + b$, where a and b are constants. Definitions of mean, variance of univariate distributions. Effect of change of origin and scale on mean and variance. Definition of raw and central moments and factorial moments up to order 2. Definition of probability generating function (p.g.f.) of a random variable. Effect of change of origin and scale. Definition of mean and variance by using p.g.f. Simple Examples.

1.3 Some Standard Discrete Probability Distributions:

Bernoulli Distribution: p.m.f., mean, variance, distribution of sum of independent and identically distributing Bernoulli variables.

Discrete Uniform Distribution: p.m.f. mean and variance.

Binomial Distribution: p.m.f.

$$P(x) = {}^{n}C_{x}\, p^{x}\, q^{n-x} \quad , \ x = 0,1,2,...n \quad 0 \le p \le 1, \quad q = 1 - p$$
$$= 0 \quad , \ otherwise$$

Notation: $X \sim B(n, p),$ recurrence relation for successive probabilities, computation of probabilities of different events. p.g.f. and hence or otherwise mean and variance, Examples.

Hypergeometric Distribution: p.m.f.

$$P(x) = \frac{{}^{M}C_{x}\ {}^{N-M}C_{n-x}}{{}^{N}C_{n}} \quad , \ x = 0,1,2,...\min(n, M)$$
$$= 0 \quad , \ otherwise$$

Notation: $X \sim H(N, M, n),$ mean and variance of distribution assuming $n \le N - M \le M$. Examples.

Unit-2: Standard Distributions and Bivariate Distributions (15 hrs.)

2.1 Some Standard Discrete Probability Distributions: Definition of discrete random variable (defined on countably infinite sample space)

Poisson Distribution: p. m. f.

$$P(x) = \frac{e^{-\lambda}\lambda^x}{x!} \quad , x = 0,1,2..... \ \lambda > 0$$
$$= 0 \quad , \ otherwise$$

Notation: $X \sim P(\lambda)$, Mean, variance, moment generating function (m. g. f.). Recurrence relation for successive Probabilities, Additive property of Poisson distribution. For X and Y independent random variables conditional distribution of X given X+Y = n. Poisson distribution as a limiting case of Binomial distribution (without proof), numerical problems.

Geometric Distribution: p. m. f.

$$P(x) = q^x p \quad , x = 0,1,2,3,.... \ 0 < p < 1, \ \ q = 1 - p$$
$$= 0 \quad , \ otherwise$$

Notation: $X \sim G(p)$, Mean, Variance, distribution function, m. g. f., Lack of memory property,

Negative Binomial Distribution: p. m. f.

$$P(x) = \binom{x+k-1}{k-1} p^k \ q^x \quad , \ x = 0,1,2,3,.... \ \ k > 0$$
$$= 0 \quad , \ otherwise$$

Notation: $X \sim NB(k, p)$, Geometric distribution is a particular case of Negative Binomial distribution, Mean, Variance, m. g. f., Recurrence relation for successive probabilities, numerical problems.

2.2 Bivariate Discrete Distribution: Definition of bivariate discrete random variable (X,Y) on finite support, Joint p.m.f., and c.d.f., Properties of c.d.f.(without proof), computation of probabilities of events in bivariate probability distribution, marginal and conditional probability distribution. Independence of two discrete r.v.s.

2.3 Mathematical Expectation (Bivariate random variable): Definition of expectation of function of r.v. in bivariate distribution. Theorems on expectation: (i) E(X+Y) = E(X) +E(Y) (ii) E(XY) = E(X). E(Y) when X and Y are independent. Expectation and variance of linear combination of two discrete r.v.s. Definition of conditional mean, conditional variance. Covariance and correlation coefficient. Cov(aX+bY, cX+dY). Distinction between uncorrelated and independent variables. Proof of the p.g.f. of sum of two independent r.v. as the product of their p.g.f.s.

Reference Books:

1. Agarwal B. L. (2003). Programmed Statistics, Second Edition, New Age International Publisher, New Delhi.
2. Bhat B. R., Srivenkatramana T. and Rao Madhava, K. S. (1996). Statistics: A Beginner's Text: Vil. I, New Age International (P) Ltd.
3. Goon A. M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I and II, 8^{th} Edition, The World Press Pvt. Ltd. Kolkata.
4. Gupta S. P. (2002): Statistical Methods, Sultan Chand and Sons, New Delhi.

5. Gupta V.K. and Kapoor S.C.: Fundamentals of Mathematical Statistics-Sultan & Chand.

Minor	DSC2-4	Theory	Introduction to Continuous Probability Distributions	Credits: 02 Hours: 30

Course Outcomes:

After successful completion of this course, students are expected to:

1. Acquire the concept of Univariate continuous distribution, various measures of continuous r.v.s, and probabilities using its probability distribution.
2. Understand bivariate continuous distributions, independence of bivariate r.v.s, Mathematical expectation of bivariate continuous distribution
3. Transform univariate and bivariate continuous random variable.
4. Acquire the knowledge of uniform, exponential, gamma and beta distribution along with their basic properties.

Course Content

Unit-1: **Continuous Univariate and Bivariate Distributions** **(15 hrs.)**

1.1 Continuous Univariate Distributions: Definition of continuous sample space with illustrations, Definition of continuous random variable (r. v.), probability density function (p. d. f.), cumulative distribution function (c. d. f.) and its properties. Expectation of a r. v., expectation of a function of r. v., mean, median, mode, quartiles, variance, harmonic mean, geometric mean, raw and central moments, problems.

Moments generating function (m. g. f.): definition and properties

(i) Standardization property $M_X(0)=1$, (ii) Effect of change of origin and scale,

(iii) Uniqueness property of m. g. f., (if exists, statement only).

Generation of raw and central moments.

Cumulant generating function (c. g. f.): definition, relations between cumulants and

central moments (up to order four). Problems.

2.2 Continuous Bivariate Distributions: Definition of bivariate continuous r. v. (X, Y), Joint p. d. f., c. d. f with properties, marginal and conditional distribution, independence of r.v.s, evaluation of probabilities of various regions bounded by straight lines. Expectation of function of r.v.s, mean, variance, covariance, correlation coefficient, conditional expectation, regression as conditional expectation if it is linear function of other variable and conditional variance, proof of:

i) $E(X \pm Y) = E(X) \pm E(Y)$, ii) $E\left[E\left(X/Y\right)\right] = E(X)$

If X and Y are independent r.v.s, then

(i) $E(XY) = E(X)\ E(Y)$,

(ii) $M_{X+Y}(t) = M_x(t) \times M_y(t)$

(iii) $M_{X,Y}(t_1,t_2) = M_x(t_1,0) \times M_y(0,t_2)$,

(iv) $M_{X+Y}(t,t) = M_x(t,0) \times M_y(0,t) = M_{X+Y}(t)$.

Numerical Problems.

2.3 Transformations of a continuous random variable: Transformation of a univariate continuous r. v.: Distribution of Y = g(X), where g is monotonic or non-monotonic function using the following methods:
(i) Jacobian of transformation, (ii) Distribution function and (iii) m.g.f. methods. Transformation of a continuous bivariate r.v.s: Distribution of a bivariate r.v.s using Jacobin of transformation. Problems.

Unit-2: Uniform, Exponential, Gamma and Beta distributions (15 hrs.)

2.1 Uniform Distribution: p. d. f. of Uniform distribution

$$f(x) = \frac{1}{b-a} \quad ; a < x < b, \quad a < b$$
$$= 0 \quad ; \ otherwise$$

Notation $X \sim U(a,b)$, c.d.f., m.g.f., mean, variance, moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients. Distribution of (i) $\frac{X-a}{b-a}$, ii) $\frac{b-X}{b-a}$, (iii) $Y = F(x)$ where $F(x)$ is c.d.f. of any continuous r.v. Problems.

2.2 Exponential distribution: (one parameter): p.d.f.

$$f(x) = \theta e^{-\theta x} \quad , 0 < x < \infty, \quad \theta > 0$$
$$= 0 \quad , \ otherwise$$

Notation $X \sim Exp(\theta)$, c.d.f., m.g.f., c.g.f., mean, variance, C.V., moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients, median, quartiles, lack of memory property, distribution of $Y = -\frac{1}{\theta}\log X$ where $X \sim U(0,1)$.Exponential distribution with scale and location parameters.

2.3Gamma distribution: p.d.f. (two parameters)

$$f(x) = \frac{\alpha^{\lambda}}{\Gamma\lambda} e^{-\alpha x} x^{\lambda-1} \quad , \ x > 0, \alpha > 0, \ \lambda > 0$$
$$= 0 \quad , \ \text{otherwise}$$

Notation $X \sim G(\alpha,\lambda)$, special cases i) $\alpha = 1$,$ii)$ $\lambda = 1$, m.g.f., c.g.f., mean mode, variance, moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients, additive property, distribution of sum of i. i. d. exponential variates.

2.4 Beta distribution of first kind: p. d. f.

$$f(x) = \frac{1}{\beta(m,n)} x^{m-1}(1-x)^{n-1} \quad , \ 0 < x < 1, m,n > 0$$
$$= 0 \quad , \ \text{otherwise}$$

Notation $X \sim \beta_1(m,n)$ symmetry around mean when $m = n$, mean, harmonic mean, mode, variance, Uniform distribution as a particular case when $m = n = 1$, distribution of $(1 - X)$.

2.5 Beta distribution of second kind: p. d. f.

$$f(x) = \frac{1}{\beta(m,n)} \frac{x^{m-1}}{(1+x)^{m+n}} \quad , \; x > 0, m, n > 0$$
$$= 0 \quad , \; \text{otherwise}$$

Notation $X \sim \beta 2_1(m,n))$ mean, harmonic mean, mode, variance, distribution of $\left(\frac{1}{X}\right)$, relation between beta distribution of first kind and second kind, distribution of $X + Y$, $\left(\frac{X}{Y}\right)$ and $\left(\frac{X}{X+Y}\right)$ where X and Y are independent gamma variate.

DSC2-3 (P)	Practical	Statistics Practical(Minor)-I	Credits: 01 Hours: 30

Course Outcomes:

At the end of this course students are expected to be able to

1. Compute the probabilities of univariate probability distributions.
2. Compute the probabilities of Binomial, Hypergeometric distributions.
3. Compute the probabilities of Poisson, Geometric and Negative Binomial, distributions.
4. Compute the marginal and conditional probabilities and expectations and conditional expectations and variances.

List of Practical's

1	Application of Univariate Probability Distribution
2	Application of Binomial Distribution
3	Application of Hypergeometric Distribution
4	Application of Poisson Distribution
5	Application of Geometric and Negative Binomial Distribution
6	Bivariate Discrete Distribution – I (Marginal and Conditional Distribution)
7	Bivariate Discrete Distribution – II (Expectation /conditional expectation / variance / conditional variance /covariance / correlation coefficient)

DSC2-4 (P)	Practical	Statistics Practical(Minor)-I	Credits: 01 Hours: 30

Course Outcomes:

At the end of this course students are expected to be able to

1. Compute the marginal and conditional distributions of a bivariate continuous random

variables.

2. Compute the expectation and conditional expectation, variances, covariance and correlation coefficients of a bivariate continuous random variables.
3. Find the probability distribution of random variables using transformations of univariate and bivariate continuous distribution.

List of Practical's

1	Bivariate Continuous distribution-I. (Marginal and conditional distribution, computation of probabilities of events).
2	Bivariate Continuous distribution-II (Expectation /conditional expectation / variance / conditional variance /covariance / correlation coefficient)
3	Transformation of univariate and bivariate continuous distribution.
4	Application of Continuous Uniform Distribution
5	Application of Exponential Distribution
6	Application of Gamma Distribution
7	Application of Beta Distribution of first kind and second kind

OE-3	**Theory**	**Probability Theory**	**Credits: 02** **Hours: 30**

Course Outcomes:

After successful completion of this course, students are expected to:

1. Understand the difference between random and nonrandom experiments.
2. Calculate probabilities and conditional probabilities.
3. Identify the types of events.
4. Apply the concept of probability in real-life situations.
5. Solve real life problems using correlation and regression.

Course Content

Course Content

Unit-1: Introduction to Probability **(15 hrs.)**

1.1 Sample Space and Events: Concepts of experiments and random experiments. Definitions: Sample space, discrete sample space (finite and countably infinite), event, elementary event, compound event favorable event. Definitions of mutually exclusive events, exhaustive events, impossible events, certain event. Power set $P(\Omega)$ (sample space consisting at most 3 sample points). Illustrative examples.

1.2 Probability: Equally likely outcomes (events), apriori (classical) definition of probability of an event, axiomatic definition of probability with reference to a finite and countably infinite sample space.

1.3 Results (with proof):

i) $P(\Phi) = 0$

ii) $P(A^C) = 1 - P(A)$

iii) $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ and its generalization (Statement only).

iv) If $A \subset B$ then $P(A) \le P(B)$

v) $0 \le P(A \cap B) \le \min\{P(A),\ P(B)\} \le P(A \cup B) \le [P(A) + P(B)]$

1.4 Conditional Probability: Definition of conditional probability of an event. Multiplication theorem for two events. Partition of sample space. Idea of Posteriori probability, Statement and proof of Baye's theorem. Examples and Problems.

1.5 Independence of Events: Concept of Independence of two events. Proof of the result that if A and B are independent then, i) A and B^c, ii) A^c and B, iii) A^c and B^c are independent. Pairwise and Mutual Independence for three events. Examples and Problems.

Unit-2: **Univariate Probability Distribution and Mathematical Expectation (15 hrs.)**

2.1 Univariate Probability Distribution: (Defined on finite and countable infinite sample space)

Definition of discrete random variables, Probability mass function (p.m.f.) and cumulative distribution function (c.d.f.), a discrete random variable, properties of c.d.f. (statements only), Probability distribution of function of a random variable, Median and Mode of a univariate discrete probability distribution, numerical problems

2.2 Mathematical Expectation (Univariate Random Variable): Definition of expectation of a random variable, expectation of a function of a random variable. Results on expectation: i) $E(c) = c,$ where c is a constant. ii) $E(aX + b) = aE(X) + b$, where a and b are constants. Definitions of mean, variance of univariate distributions. Effect of change of origin and scale on mean and variance. Definition of raw and central moments and factorial moments up to order 2. Definition of probability generating function (p.g.f.) of a random variable. Effect of change of origin and scale. Definition of mean and variance by using p.g.f. Simple Examples.

Reference Books:

1. Agarwal B. L. (2003). Programmed Statistics, Second Edition, New Age International Publisher, New Delhi.
2. Bhat B. R., Srivenkatramana T. and Rao Madhava, K. S. (1996). Statistics: A Beginner's Text: Vil. I, New Age International (P) Ltd.
3. Goon A. M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I and II, 8th Edition, The World Press Pvt. Ltd. Kolkata.
4. Gupta S. P. (2002): Statistical Methods, Sultan Chand and Sons, New Delhi.

5. Gupta V.K. and Kapoor S.C.: Fundamentals of Mathematical Statistics-Sultan & Chand.

VSC-1	Practical	Practical Related to Major-I	Credits: 02 Hours: 60

Course Outcomes:

At the end of the course, students are able to

1. Use MS-Excel in daily life.
2. Create spreadsheets, enter data, and maintain data in MS-Excel.
3. Handle data using existing MS-Excel functions.
4. Perform data analysis, generate summary statistics, and visualize data by using MS-Excel.
5. Present the available data graphically using MS-Excel.

Course Content

List of Practical's

1	Fitting of Discrete Uniform and Binomial Distribution
2	Fitting of Hypergeometric Distribution
3	Fitting of Poisson and Geometric Distribution
4	Fitting of Negative Binomial Distribution
5	Model Sampling of Discrete Uniform and Binomial Distribution
6	Model Sampling of Hypergeometric Distribution
7	Model Sampling of Poisson and Geometric Distribution
8	Model Sampling of Negative Binomial Distribution
9	Multiple Regression
10	Multiple and Partial correlation

Reference Books:

1. Frag Curtis (2013). Step by Step Microsoft Excel 2013, MS Press.
2. Frye Curtis D. (2007). Step by step Microsoft Office Excel 2007, Microsoft Press.
3. John Walkenbach (2013). 101 Excel 2013 Tips, Tricks and Time severs, Wiley.
4. Kumar Bittu (2013). Microsoft Office 2010, V and S Publishers.
5. Salkind Neil J. and Frey Bruce B. (2021). Statistics for people who (Think They) Hate Statistics, Using MS- Excel, Sage Publications.
6. Sanjay Saxena (2007). MS Office 2000 for everyone, Vikas Publishing House.

VSC-2	Practical	Practical Related to Minor-I	Credits: 02 Hours: 60

Course Outcomes:

At the end of the course, students are able to

1. Use MS-Excel in daily life.

2. Create spreadsheets, enter data, and maintain data in MS-Excel.
3. Handle data using existing MS-Excel functions.
4. Perform data analysis, generate summary statistics, and visualize data by using MS-Excel.
5. Present the available data graphically using MS-Excel.

Course Content

List of Practical's

1	Fitting of Discrete Uniform and Binomial Distribution
2	Fitting of Hypergeometric Distribution
3	Fitting of Poisson and Geometric Distribution
4	Fitting of Negative Binomial Distribution
5	Model Sampling of Discrete Uniform and Binomial Distribution
6	Model Sampling of Hypergeometric Distribution
7	Model Sampling of Poisson and Geometric Distribution
8	Model Sampling of Negative Binomial Distribution
9	Fitting of Continuous Uniform and Exponential Distribution
10	Model sampling of Continuous Uniform and Exponential Distribution

Reference Books:

7. Frag Curtis (2013). Step by Step Microsoft Excel 2013, MS Press.
8. Frye Curtis D. (2007). Step by step Microsoft Office Excel 2007, Microsoft Press.
9. John Walkenbach (2013). 101 Excel 2013 Tips, Tricks and Time severs, Wiley.
10. Kumar Bittu (2013). Microsoft Office 2010, V and S Publishers.
11. Salkind Neil J. and Frey Bruce B. (2021). Statistics for people who (Think They) Hate Statistics, Using MS- Excel, Sage Publications.
12. Sanjay Saxena (2007). MS Office 2000 for everyone, Vikas Publishing House.

B. Sc. Part-II (Statistics) Semester-IV

Major	**DSC1-5**	**Theory**	**Continuous Probability Distributions-II**	**Credits: 02** **Hours: 30**

Course Outcomes: At the end of this course, **s**tudents will acquire knowledge of:
1. Uniform, exponential and beta distribution along with their basic properties.
2. Normal and standard normal distribution and its wide applications
3. Exact sampling distributions that are used in inferential procedures.

Course Content

Unit-1: **(15 hrs.)**

1.1 Uniform Distribution: p. d. f. of Uniform distribution

$$f(x) = \frac{1}{b-a} \quad ; a < x < b, \quad a < b$$
$$= 0 \quad ; \ otherwise$$

Notation $X \sim U(a,b)$, c.d.f., m.g.f., mean, variance, moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients. Distribution of (i) $\frac{X-a}{b-a}$, ii) $\frac{b-X}{b-a}$, (iii) $Y = F(x)$ where $F(x)$ is c.d.f. of any continuous r.v. Problems.

1.2 Exponential distribution: (one parameter): p.d.f.

$$f(x) = \theta e^{-\theta x} \quad ,0 < x < \infty, \quad \theta > 0$$
$$= 0 \quad , \ otherwise$$

Notation $X \sim Exp(\theta)$, c.d.f., m.g.f., c.g.f., mean, variance, C.V., moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients, median, quartiles, lack of memory property, distribution of $Y = -\frac{1}{\theta}\log X$ where $X \sim U(0,1)$.Exponential distribution with scale and location parameters.

1.3Gamma distribution: p.d.f. (two parameters)

$$f(x) = \frac{\alpha^{\lambda}}{\Gamma\lambda} e^{-\alpha x} x^{\lambda-1} \quad , \ x > 0, \alpha > 0, \ \lambda > 0$$
$$= 0 \quad , \ \text{otherwise}$$

Notation $X \sim G(\alpha,\lambda)$, special cases i) $\alpha = 1$,$ii)$ $\lambda = 1$, m.g.f., c.g.f., mean mode, variance, moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients, additive property, distribution of sum of i. i. d. exponential variates.

1.4 Beta distribution of first kind: p. d. f.

$$f(x) = \frac{1}{\beta(m,n)} x^{m-1}(1-x)^{n-1} \quad , \ 0 < x < 1, m, n > 0$$
$$= 0 \quad , \ \text{otherwise}$$

Notation $X \sim \beta_1(m,n)$ symmetry around mean when $m = n$, mean, harmonic mean, mode, variance, Uniform distribution as a particular case when $m = n = 1$, distribution of $(1-X)$.

1.5 Beta distribution of second kind: p. d. f.

$$f(x) = \frac{1}{\beta(m,n)} \frac{x^{m-1}}{(1+x)^{m+n}} \quad , \ x > 0, m, n > 0$$
$$= 0 \quad , \ \text{otherwise}$$

Notation $X \sim \beta2_1(m,n)$) mean, harmonic mean, mode, variance, distribution of $\left(\frac{1}{X}\right)$, relation between beta distribution of first kind and second kind, distribution of $X+Y$, $\left(\frac{X}{Y}\right)$ and $\left(\frac{X}{X+Y}\right)$ where X and Y are independent gamma variate.

Unit-2: **(15 hrs.)**

2.1 Normal Distribution: p. d. f.

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \quad , -\infty < x < \infty, \quad -\infty < \mu < \infty, \quad \sigma > 0$$
$$= 0 \quad , \textit{otherwise}$$

Notation $X \sim N(\mu, \sigma^2)$ definition of standard normal distribution, properties of normal curve, m. g. f., c.g.f., mean, variance, median, mode, mean deviation, quartiles, point of inflexion, moments, recurrence relation for central moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients, standard normal distribution, additive property, distribution of X^2 if $X \sim N(0,1)$, distribution of $aX + bY + c$ when X and Y are independent normal r.v.s. Normal as a limiting case of i) Binomial ii) Poisson (without proof), illustrations of use of normal distribution in various fields.

2.2 Exact Sampling Distributions

Chi-Square distribution: Definition of chi square variate as a sum of square of n i. i. d. standard normal variates, derivation of p.d.f. of chi square distribution with n degrees of freedom using m.g.f., c.g.f., mean, mode, variance, moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients, m. g. f. additive property, relation with gamma distribution. Normal approximation to chi square distribution using central limit theorem.

Student's t- distribution: Definition of student's t variate in the form $t = \frac{U}{\sqrt{\frac{\chi^2}{n}}}$ where $U \sim N(0,1)$ and χ^2 is chi-square variate with n d. f. Derivation of p.d.f., mean, mode, variance, moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients.

Snedecor's F distribution: Definition of F variate with n_1, n_2 d.f. as a ratio of two independent chi-square variables divided by their respective degrees of freedom. Derivation of p.d.f., mean, variance and mode. Distribution of $\frac{1}{F}$. Interrelation between t, F and χ^2.

Reference Books:

6. Agarwal B. L. (2003). Programmed Statistics, Second Edition, New Age International Publisher, New Delhi.
7. Bhat B. R., Srivenkatramana T. and Rao Madhava, K. S. (1996). Statistics: A Beginner's Text: Vil. I, New Age International (P) Ltd.
8. Goon A. M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I and II, 8th Edition, The World Press Pvt. Ltd. Kolkata.
9. Gupta S. P. (2002): Statistical Methods, Sultan Chand and Sons, New Delhi.
10. Gupta V.K. and Kapoor S.C.: Fundamentals of Mathematical Statistics-Sultan & Chand.

Major	DSC1-6	Theory	Statistical Methods	Credits: 02 Hours: 30

Course Outcomes: After the successful completion of this course, students will acquire knowledge of:

1. Sampling theory and its need.
2. Different methods of sampling and estimators associated with them.

3. Different rates with respect to population change.
4. The inferential procedure for large as well as small samples.

Course Content

Unit 1: Sampling Theory and Demography **(15 hrs.)**

1.1 Sampling Theory: Definition of population, sample, parameter, statistic, sample survey, census survey. Advantages of sample survey over census survey, estimator, unbiased estimator. Methods of sampling: i) Deliberate (purposive) sampling ii) probability sampling and iii) Mixed sampling.

Simple random sampling without replacement (SRSWOR): Some results:

i) Probability of a specified unit being selected in sample at any given draw is equal to $\frac{1}{N}$.

ii) Probability of a specific unit being included in the sample is $\frac{n}{N}$.

iii) Probability of drawing a specific sample of size 'n' from a population of size N units is $\frac{1}{\binom{N}{n}}$

iv) $E(\bar{y}_n) = \bar{Y}_N$

v) $E(N\bar{y}_n) = \sum Y_i =$ Population total

vi) $Var(\bar{y}_n) = \frac{(N-n)}{Nn} S^2$

vii) $E(s^2) = S^2$ viii) Estimated variance of sample mean

Simple random sampling with replacement (SRSWR): Some results:

i) $E(\bar{y}_n) = \bar{Y}_N$

ii) $E(N\bar{y}_n) = \sum Y_i =$ Population total

iii) $Var(\bar{y}_n) = \frac{(N-1)}{Nn} S^2$

iv) Estimated variance of sample mean

Standard error of sample means, comparison of SRSWR and SRSWOR.

1.2 Demography: Introduction, vital events and need of vital statistics, Measures of fertility: Crude Birth Rate (CBR), Age Specific Fertility Rate (ASFR), General Fertility Rate (GFR), Total Fertility Rate (TFR), Measures of reproduction: Gross Reproduction rate (GRR), Net Reproduction Rate (NRR), Measures of mortality: Crude death rate (CDR), Specific Death Rate (SDR) by i) Direct method ii) Indirect method, Standardized Death Rate (STDR), Population projection at time t, Life Table - construction and its applications in insurance, Use and Applications

Unit 2: Testing of Hypothesis: **(27 hrs.)**

2.1Testing of Hypothesis: Notion of Population, Sample, Parameter, Statistic, Sampling distribution of Statistic, hypothesis, Simple and composite hypothesis, Null and alternative hypothesis, type I and type II errors, Critical region, level of significance, one and two tailed test, power of test. General procedure of testing of hypothesis.

2.2: Large Sample Tests: a) Tests for means: i) testing of population mean; $H_o : \mu = \mu_0$,

ii) testing equality of population means; $H_o : \mu_1 = \mu_2$

b) Tests for Proportion: i) testing of population Proportion; $H_o : P = P_0$

ii) testing equality of population Proportion; $H_o : P_1 = P_2$

c) test for population correlation: i) $H_o : \rho = \rho_0$ ii) $H_o : \rho_1 = \rho_2$ (by Z-transformation)

2.3: Small sample tests: Definition of Fisher's $t-$ variate,

$t-$ test: a) test for means: i) $H_o : \mu = \mu_0$, ii) $H_o : \mu_1 = \mu_2$, ($\sigma_1 = \sigma_2$), iii) Paired $t-$ test

$\chi^2 -$ test: i) test for population variance $H_o = \sigma^2 = \sigma_0^2$ (Mean known and unknown),

ii) test for goodness of fit, iii) test for independence of attributes: a) $m \times n$ contingency table,

b) 2×2 contingency table, test statistic with proof. Yate's correction for continuity.

F – test: test for equality of two population variances $H_o = \sigma_1^2 = \sigma_2^2$

References

1. Cochran, W.G: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
2. Des Raj: Sampling Theory.
3. Gupta S. C. and Kapoor V. K., "Fundamentals of Applied Statistics", Sultan and Chand, (2010).
4. Dr. Kore B. G. and Dr. Dixit P. G.: "Statistical Methods-I", Nirali Prakashan, Pune.
5. Mukhopadhay, Parimal: Theory and Methods of Survey Sampling, Prentice Hall.
6. Sukhatme, P.V. and Sukhatme, B.V.: Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi
7. Dr. Kore B. G. and Dr. Dixit P. G.: "Statistical Methods-II", Nirali Prakashan, Pune.
8. Snedecor G.W. and Cochran W. G. "Statistical Methods", Iowa State University Press.

DSC1-5 (P)	**Practical**	**Statistics Practical (Major)-V**	**Credits: 01 Hours: 30**

Course Outcomes:

At the end of this course students are expected to be able to

1. Compute probabilities of standard probability distributions.
2. Compute the expected frequency and test the goodness of fit.
3. Draw random samples from standard probability distributions.
4. Acquire the knowledge of exponential, normal, gamma and beta distributions.

List of Practical's

1	Fitting of Continuous Uniform and Exponential distribution and test for goodness of fit.
2	Fitting of Normal distribution and test for goodness of fit.
3	Model sampling from Continuous Uniform and Exponential distribution.
4	Model sampling from Normal distribution
5	Applications of Exponential distribution.
6	Applications of Normal distribution.
7	Applications of Gamma and Beta distributions.

DSC1-6 (P)	**Practical**	**Statistics Practical (Major)-VI**	**Credits: 01** **Hours: 30**

Course Outcomes:

At the end of this course students are expected to be able to

1. Understand the fundamental concepts of sampling theory.
2. Understand different rates w.r.t. population and their applications.
3. Test various hypotheses encountered in various real-life situations.

List of Practical's

1	Simple Random Sampling with Replacement and without Replacement
2	Demography-I (Mortality Rates, Fertility Rates, Reproduction rates)
3	Large sample tests for means and proportions
4	Tests for population correlation coefficients (Using Fisher's Z transformation)
5	Tests based on Chi-square distribution.
6	Tests based on t distribution
7	Tests based on F distribution ($\sigma_1^2 = \sigma_2^2$)

Minor	**DSC2-5**	**Theory**	**Theory of Testing of Hypotheses**	**Credits: 02** **Hours: 30**

Course Outcomes:

After successful completion of this course, students are expected to:

1. Understand various exact sampling distributions and their applications.
2. Perform various small sample tests.
3. Perform various large sample tests.

Course Content

Unit-2: Sampling Distributions **(15 hrs.)**

2.1 Normal Distribution: p. d. f.

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \quad , -\infty < x < \infty, \;\; -\infty < \mu < \infty, \;\; \sigma > 0$$
$$= 0 \quad , \textit{otherwise}$$

Notation $X \sim N(\mu, \sigma^2)$ definition of standard normal distribution, properties of normal curve, m. g. f., c.g.f., mean, variance, median, mode, mean deviation, quartiles, point of inflexion, moments, recurrence relation for central moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients, standard normal distribution, additive property, distribution of X^2 if $X \sim N(0,1)$, distribution of $aX + bY + c$ when X and Y are independent normal r.v.s. Normal as a limiting case of i) Binomial ii) Poisson (without proof), illustrations of use of normal distribution in various fields.

2.2 Exact Sampling Distributions

Chi-Square distribution: Definition of chi square variate as a sum of square of n i. i. d. standard normal variates, derivation of p.d.f. of chi square distribution with n degrees of freedom using m.g.f., c.g.f., mean, mode, variance, moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients, m. g. f. additive property, relation with gamma distribution. Normal approximation to chi square distribution using central limit theorem.

Student's t- distribution: Definition of student's t variate in the form $t = \frac{U}{\sqrt{\frac{\chi^2}{n}}}$ where $U \sim N(0,1)$ and χ^2 is chi-square variate with n d. f. Derivation of p.d.f., mean, mode, variance, moments, $\beta_1, \beta_2, \gamma_1$ and γ_2 coefficients.

Snedecor's F distribution: Definition of F variate with n_1, n_2 d.f. as a ratio of two independent chi-square variables divided by their respective degrees of freedom. Derivation of p.d.f., mean, variance and mode. Distribution of $\frac{1}{F}$. Interrelation between t, F and χ^2.

Unit 2: Testing of Hypothesis: **(27 hrs.)**

2.1Testing of Hypothesis: Notion of Population, Sample, Parameter, Statistic, Sampling distribution of Statistic, hypothesis, Simple and composite hypothesis, Null and alternative hypothesis, type I and type II errors, Critical region, level of significance, one and two tailed test, power of test. General procedure of testing of hypothesis.

2.2: Large Sample Tests: a) Tests for means: i) testing of population mean; $H_o : \mu = \mu_0$,

ii) testing equality of population means; $H_o : \mu_1 = \mu_2$

b) Tests for Proportion: i) testing of population Proportion; $H_o : P = P_0$

ii) testing equality of population Proportion; $H_o : P_1 = P_2$

c) test for population correlation: i) $H_o : \rho = \rho_0$ ii) $H_o : \rho_1 = \rho_2$ (by Z-transformation)

2.3: Small sample tests: Definition of Fisher's $t-$ variate,

$t-$ test: a) test for means: i) $H_o : \mu = \mu_0$, ii) $H_o : \mu_1 = \mu_2$, ($\sigma_1 = \sigma_2$), iii) Paired $t-$ test

$\chi^2 -$ test: i) test for population variance $H_o = \sigma^2 = \sigma_0^2$ (Mean known and unknown),

ii) test for goodness of fit, iii) test for independence of attributes: a) $m \times n$ contingency table, b) 2×2 contingency table, test statistic with proof. Yate's correction for continuity.

F – test: test for equality of two population variances $H_o = \sigma_1^2 = \sigma_2^2$

Reference Books:

1. Agarwal B. L. (2003). Programmed Statistics, Second Edition, New Age International Publisher, New Delhi.
2. Bhat B. R., Srivenkatramana T. and Rao Madhava, K. S. (1996). Statistics: A Beginner's Text: Vil. I, New Age International (P) Ltd.
3. Goon A. M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I and II, 8th Edition, The World Press Pvt. Ltd. Kolkata.
4. Gupta S. P. (2002): Statistical Methods, Sultan Chand and Sons, New Delhi.
5. Gupta V.K. and Kapoor S.C.: Fundamentals of Mathematical Statistics-Sultan & Chand.

Minor	DSC2-6	Theory	Applied Statistics	Credits: 02 Hours: 30

Course Outcomes:

After successful completion of this course, students are expected to:

1. Apply multiple correlation and regression techniques to the real life datasets.
2. Apply partial correlation techniques to the real life datasets.
3. Understand sampling techniques to the real life situations.
4. Understand various rates w.r.t. population and their applications.

Course Content

Unit-1: Multiple Correlation and Regression (15 hrs.)

1.1 Multiple Linear Regression (for trivariate data only): Concept of multiple linear regression, Plane of regression, Yule's notation, correlation matrix. Fitting of regression plane by method of least squares, definition of partial regression coefficients and their interpretation. Residual: definition, order, properties, derivation of mean and variance, covariance between residuals.

1.2 Multiple and Partial Correlation (for trivariate data only): Concept of multiple correlation. Definition of multiple correlation coefficient Ri.jk, derivation of formula for multiple correlation coefficient. Properties of multiple correlation coefficient:
i) 0 ≤Ri.jk≤1, (ii) Ri.jk>max{|rij|, |rik|, |rij.k|, |rik.j| }
(iii) Ri.jk≥ |rik| i = j =k = 1, 2, 3. i≠j, i≠k. Interpretation of Ri.jk =1, Ri.jk = 0, coefficient of multiple determination $Rij.k$

Concept of partial correlation. Definition of partial correlation coefficient rij.k. Properties of partial correlation coefficient; (i) -1 ≤rij.k≤1, (ii) $bij.k \times bji.k = rij.k$ Numerical problems.

Unit 2: Sampling Theory and Demography **(15 hrs.)**

2.1 Sampling Theory: Definition of population, sample, parameter, statistic, sample survey, census survey. Advantages of sample survey over census survey, estimator, unbiased estimator. Methods of sampling: i) Deliberate (purposive) sampling ii) probability sampling and iii) Mixed sampling.

Simple random sampling without replacement (SRSWOR): Some results:

i) Probability of a specified unit being selected in sample at any given draw is equal to $\frac{1}{N}$.

ii) Probability of a specific unit being included in the sample is $\frac{n}{N}$.

iii) Probability of drawing a specific sample of size 'n' from a population of size N units is $\frac{1}{\binom{N}{n}}$

iv) $E(\overline{y}_n) = \overline{Y}_N$

v) $E(N\overline{y}_n) = \sum Y_i =$ Population total

vi) $Var(\overline{y}_n) = \frac{(N-n)}{Nn}S^2$

vii) $E(s^2) = S^2$ viii) Estimated variance of sample mean

Simple random sampling with replacement (SRSWR): Some results:

i) $E(\overline{y}_n) = \overline{Y}_N$

ii) $E(N\overline{y}_n) = \sum Y_i =$ Population total

iii) $Var(\overline{y}_n) = \frac{(N-1)}{Nn}S^2$

iv) Estimated variance of sample mean

Standard error of sample means, comparison of SRSWR and SRSWOR.

2.2 Demography: Introduction, vital events and need of vital statistics, Measures of fertility: Crude Birth Rate (CBR), Age Specific Fertility Rate (ASFR), General Fertility Rate (GFR), Total Fertility Rate (TFR), Measures of reproduction: Gross Reproduction rate (GRR), Net Reproduction Rate (NRR), Measures of mortality: Crude death rate (CDR), Specific Death Rate (SDR) by i) Direct method ii) Indirect method, Standardized Death Rate (STDR), Population projection at time t, Life Table - construction and its applications in insurance, Use and Applications

DSC2-5 (P)	Practical	Statistics Practical (Minor)-III	Credits: 01 Hours: 30

Course Outcomes:

At the end of this course students are expected to be able to

1. Understand the applications of Normal distribution.
2. Understand practical situations where the concept of testing of hypotheses can be used.
3. Apply various tests to check correctness of the hypotheses.

List of Practical's

1	Applications of Normal distribution.
2	Large sample tests for means and proportions
3	Tests for population correlation coefficients (Using Fisher's Z transformation)
4	Tests based on Chi-square distribution.
5	Tests of Independence.
6	Tests based on t distribution
7	Tests based on F distribution ($\sigma_1^2 = \sigma_2^2$)

DSC2-6 (P)	Practical	Statistics Practical (Minor)-IV	Credits: 01 Hours: 30

Course Outcomes:

At the end of this course students are expected to be able to

1. Understand the concept of multiple and partial correlation.
2. Understand the sampling methods and their applications.
3. Understand the applications of various rates in Demography.

List of Practical's

1	Multiple Regression
2	Multiple correlation
3	Partial correlation
4	Simple Random Sampling with Replacement
5	Simple Random Sampling without Replacement
6	Demography-I (Mortality Rates)
7	Demography-II (Fertility Rates, Reproduction rates)

OE-4	Theory	Applications of Statistics	Credits: 02 Hours: 30

Course Outcomes:

After successful completion of this course, students are expected to:

1. Understand difference between variable and attribute.
2. Understand the methodology to deal with data on attributes.
3. Understand and potential applications of Index numbers.

Course Content

Unit – 1 Theory of Attributes: (15 hrs.)

Theory of Attributes: Notation, dichotomy, class frequency, order of class, positive and negative class frequency, ultimate class frequency, fundamental set of class frequency, relationships among different class frequencies (up to three attributes). Concept of Consistency, conditions of consistency (up to three attributes).

Concept of Independence and Association of two attributes. Yule's coefficient of association (Q): Definition, interpretation. Coefficient of colligation (Y): Definition, Interpretation. Relation between Q and Y: $Q = \frac{2Y}{(1+Y^2)}, |Q| \geq |Y|, 0 \leq |Y| \leq |Q| \leq 1.$

Illustrative Examples.

Unit - 2 Index Numbers (15 hrs)

Index Numbers: Meaning and utility of price index numbers, problems in construction of index numbers. Unweighted price index numbers using: i) Aggregate method ii) Average of price or quantity relatives method (A. M. or G. M. to be used as average). Weighted price index numbers using aggregate method: Laspeyre's, Paasche's, Fisher's Formulae, cost of living index numbers. Tests of Index numbers (time reversal and factor reversal test). Illustrative Examples.

Reference Books:

1. Agarwal B. L. (2003). Programmed Statistics, Second Edition, New Age International Publisher, New Delhi.
2. Bhat B. R., Srivenkatramana T. and Rao Madhava, K. S. (1996). Statistics: A Beginner's Text: Vil. I, New Age International (P) Ltd.
3. Goon A. M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I and II, 8th Edition, The World Press Pvt. Ltd. Kolkata.

4. Gupta S. P. (2002): Statistical Methods, Sultan Chand and Sons, New Delhi.
5. Gupta V.K. and Kapoor S.C.: Fundamentals of Mathematical Statistics-Sultan & Chand.

VSC-3	Practical	Practical Related to Major-II	Credits: 02 Hours: 60

Course Outcomes:

At the end of the course, students are able to

1. Fit certain distributions to the available data.
2. Use various sampling methods for taking a sample.
3. Apply various statistical tests to test the hypotheses.

Course Content

List of Practical's

1	Fitting of Continuous Uniform and Exponential distribution and test for goodness of fit.
2	Fitting of Normal distribution and test for goodness of fit.
3	Model sampling from Continuous Uniform, Exponential and Normal distribution.
4	Simple Random Sampling with Replacement and without Replacement
5	Demography-I (Mortality Rates, Fertility Rates, Reproduction rates)
6	Large sample tests for means and proportions
7	Tests for population correlation coefficients (Using Fisher's Z transformation)
8	Tests based on Chi-square distribution.
9	Tests based on t distribution
10	Tests based on F distribution ($\sigma_1^2 = \sigma_2^2$)

Reference Books:

1. Frag Curtis (2013). Step by Step Microsoft Excel 2013, MS Press.
2. Frye Curtis D. (2007). Step by step Microsoft Office Excel 2007, Microsoft Press.
3. John Walkenbach (2013). 101 Excel 2013 Tips, Tricks and Time severs, Wiley.
4. Kumar Bittu (2013). Microsoft Office 2010, V and S Publishers.
5. Salkind Neil J. and Frey Bruce B. (2021). Statistics for people who (Think They) Hate Statistics, Using MS- Excel, Sage Publications.
6. Sanjay Saxena (2007). MS Office 2000 for everyone, Vikas Publishing House.

VSC-4	Practical	Practical Related to Minor-II	Credits: 02 Hours: 60

Course Outcomes:

At the end of the course, students are able to

1. Fit the normal distribution to the appropriate dataset.
2. Draw a model sample from normal distribution.
3. Perform the testing of hypotheses using statistical tests.

Course Content

List of Practical's

1	Fitting of Normal distribution
2	Model sampling from Normal distribution.
3	Simple Random Sampling with Replacement and without Replacement
4	Demography-I (Mortality Rates, Fertility Rates, Reproduction rates)
5	Multiple Regression.
6	Multiple and Partial correlation.
7	Large sample tests for means and proportions.
8	Tests based on Chi-square distribution.
9	Tests based on t distribution
10	Tests based on F distribution ($\sigma_1^2 = \sigma_2^2$)

Reference Books:

1. Frag Curtis (2013). Step by Step Microsoft Excel 2013, MS Press.
2. Frye Curtis D. (2007). Step by step Microsoft Office Excel 2007, Microsoft Press.
3. John Walkenbach (2013). 101 Excel 2013 Tips, Tricks and Time severs, Wiley.
4. Kumar Bittu (2013). Microsoft Office 2010, V and S Publishers.
5. Salkind Neil J. and Frey Bruce B. (2021). Statistics for people who (Think They) Hate Statistics, Using MS- Excel, Sage Publications.
6. Sanjay Saxena (2007). MS Office 2000 for everyone, Vikas Publishing House.

Field Project

The objective of Field Project is to train the students to undertake projects individually or in groups. The projects shall enable the students to take up their own statistical study and to understand the application of statistical methods that they learned during the course. For the project each student shall work under the supervision of a faculty member of the department.

In consultation of the supervisor, students shall decide on a topic for their Field Project. The topic shall be presented before all faculty members for approval with details objective and methodology. Once approved, the student shall work on the project. There shall be a mid- term evaluation of the project to appraise the continuous progress. Before the start of the end-semester examination, students are required to submit the project report in hard copy in duplicate. During the end of semester examination, students shall present the same, whereby they shall be evaluated by an external examiner.

Project report shall contain the Statement of Problem, Data collection, Methodology adopted, Statistical tools used for analysis, Findings, Conclusion, Suggestion and References.

Project work will be assessed for 50 marks (02 credits), out of which 20 marks are reserved for internal evaluation based on primary preparation for the project like selection of topic, preparation of questionnaire, synopsis presentation and day-to-day project work reporting, mid-term project presentation etc.

End of Term assessment of the project for 30 marks will be done on the basis of presentation, findings and report of the project, out of which 20 marks are reserved for VIVA.