S.Y. B. Sc. (STATISTICS) SEMESTER III
Core course - I
COURSE TITLE: Probability Distribution–I
COURSE CODE: 22US3STCCIPRD1 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Determine the moments, cumulants using moment generating function and cumulant generating function. 2. Evaluate various measures of the distributions and apply the appropriate probability distribution depending on the data. 3. Apply the concept of MGF, CGF to obtain the results of the probability distributions for bernoulli, binomial, Poisson, Uniform, Geometric and NBD. 4. Study the recurrence relations of pmf, raw moments, central moments and cumulants for various probability distributions. 5. Explain the concept of truncated probability distribution and determine mean and variance of truncated binomial and poisson distribution. 6. Determine the marginal, conditional, correlation coefficient and independence of the probability distributions from the joint probability distributions. 7. Apply the technique of Jacobian and cumulative transformation to obtain the probability distributions of the transformed variables. 8. Determine the moments of the joint distribution and derive the MGF of marginal distributions Using MGF properties.

Module 1	MGF, CGF, Bernoulli, Binomial and Poisson Distribution	[12L]

Learning Objectives:

This module is intended to
module is intended

1. To learn techniques such as Moment Generating Function (MGF) and Cumulant Generating Function (CGF) methods for obtaining the raw moments of the distributions.
2. To obtain various measures of the Bernoulli, Binomial and Poisson distribution using MGF and CGF.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Find the moments of the distribution using suitable method
2. Obtain various measures using MGF and CGF and understand the relationship between Bernoulli, binomial and Poisson distribution.

1.1	**Moment Generating Functions (MGF)**	[2L]
	Definition (discrete and continuous random variables), obtain probability distribution from MGF, raw moments from MGF, properties of MGF : i) MGF of aX + b ii) MGF of sum of two independent r.v.s. along with the generalization Uniqueness property (only statement).	
1.2	**Cumulant Generating Function (CGF)**	[2L]
	Definition, cumulants from CGF, properties of CGF : i) Effect of shift of origin and scale ii) Additive property of cumulants Relationship between cumulants and the moments	
1.3	**Bernoulli Distribution**	[2L]
	Definition, MGF, CGF, moments, cumulants, mean, variance, skewness and kurtosis	
1.4	**Binomial Distribution**	[3L]
	Definition, MGF, CGF, moments, cumulants, mean, variance, mode, skewness and kurtosis, recurrence relationship for binomial probabilities, recurrence relationship for raw and central moments, cumulants, additive property, fitting of the distribution	
1.5	**Poisson Distribution**	[3L]
	Definition, MGF, CGF, moments, cumulants, mean, variance, skewness and kurtosis, mode, recurrence relationship for poisson probabilities, recurrence relationship for raw and central moments, additive property, conditional distribution of X given X + Y where X and Y are independent, fitting of the distribution	

References:

- Introduction to the theory of statistics: A. M. Mood, F.A. Graybill, D. C. Boyes, Third Edition; McGraw-Hill Book Company.

- Introduction to Mathematical Statistics: R.V.Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.
- John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
- Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.
- Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.
- Mathematical Statistics: J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.
- An Outline of Statistical Theory Vol. I: A.M. Goon, M.K. Gupta, B. DasGupta; Third Edition; TheWorldPress Pvt. Ltd.

Module 2	Uniform, Geometric, Negative Binomial, Truncated Binomial and Truncated Poisson Distribution	[12L]

Learning Objectives:

This module is intended to

1. Obtain various measures of Geometric, Negative Binomial, Uniform distribution using MGF / CGF method
2. Understand the concept of the truncated distribution and derive the truncated distribution for Binomial and Poisson

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Apply various properties of MGF to the Geometric, Negative Binomial, Uniform distribution
2. Obtain the distribution of truncated Binomial and truncated Poisson distribution

2.1	**Uniform Distribution**	**[2L]**
	Definition, MGF, mean, variance, skewness, fitting of the distribution	
2.2	**Geometric Distribution (two forms)**	**[3L]**
	Definition, mean, mode, variance, distribution function, MGF, CGF, moments. Cumulants, coefficient of skewness and kurtosis, lack of memory property, obtain the distribution of $X_1 = k/ X_1 + X_2=n$	

2.3	**Negative Binomial Distribution (NBD)**	[3L]
	Definition, derivation of p.m.f., alternate form of NBD, mean, variance, MGF, CGF, monets, cumulants, skewness and kurtosis, recurrence relationship for NBD probabilities, NBD(k, p) as sum of the 'k' i.i.d. geometric variables with parameter 'p', Poisson distribution as a limiting case of NBD, fitting of the distribution	
2.4	**Truncated Probability Distribution**	[4L]
	Definition, Binomial and Truncated Poisson Distribution (truncated at O), derivation of p.m.f., mean.	

References:

- Introduction to the theory of statistics: A. M. Mood, F.A. Graybill, D. C. Boyes, Third Edition; McGraw-Hill Book Company.
- Introduction to Mathematical Statistics: R.V.Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.
- John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
- Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.
- Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.
- Mathematical Statistics: J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.
- An Outline of Statistical Theory Vol. I: A.M. Goon, M.K. Gupta, B. DasGupta; Third Edition; TheWorldPress Pvt. Ltd.

Module 3	Joint Probability Function of Two Variables and Transformation of Continuous Variables	[12L]

Learning Objectives:

The module is intended to

1. To learn probability distribution involving two random variables
2. To apply MGF method to bivariate distribution
3. To obtain the distribution of the transformed variables

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. To obtain marginal, conditional distributions
2. Check the independence of the variables using MGF

3. Derive the distribution of the transformed variables		
3.1	**Joint Probability Function**	[4L]
	Discrete and continuous bivariate random variables, their probability function along with the properties. Marginal and conditional Distributions. Independence of Random Variables. Conditional Expectation & Variance. Regression Function. Coefficient of Correlation.	
3.2	**MGF of bivariate random variable**	[3L]
	Definition, joint raw moments, M.G.F. of marginal distribution of r.v.s., properties	
3.3	**Transformation of Random Variables**	[5L]
	Probability distribution of functions of r.v.s using cumulative distribution, Jacobian transformation and MGF	

References:

- Introduction to the theory of statistics: A. M. Mood, F.A. Graybill, D. C. Boyes, Third Edition; McGraw-Hill Book Company.
- Introduction to Mathematical Statistics: R.V.Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.
- John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
- Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.
- Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.
- Mathematical Statistics: J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.
- An Outline of Statistical Theory Vol. I: A.M. Goon, M.K. Gupta, B. DasGupta; Third Edition; TheWorldPress Pvt. Ltd.

Question Paper Template

S.Y. B. Sc. (STATISTICS) SEMESTER III

Core Course- I

COURSE TITLE: Probability Distribution–I

COURSE CODE: 22US3STCCIPRDI [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	4	8	10	-	8	-	30
II	8	8	8		4	2	30
III	4	8	6	4	8		30
Total marks per objective	16	24	24	4	20	2	90
% Weightage	18	27	27	4	22	2	100

S.Y. B. Sc. (STATISTICS) SEMESTER III

Core course – II

COURSE TITLE: Sampling Techniques

COURSE CODE:22US3STCC2SAT [CREDITS – 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Explain the basic concepts & steps involved in conducting a sample survey. 2. Distinguish between the different types of errors occurring in the survey. 3. Apply different sampling techniques such as simple random sampling, stratified random sampling, cluster sampling, systematic sampling, ratio & regression methods for conducting surveys. 4. Estimate parameters using different sampling techniques. 5. Estimate sample size for different sampling techniques. 6. Compare the precision of different sampling techniques.

Module 1	Fundamentals of Sample Surveys and Simple Random Sampling	[14L]
Learning Objectives: The module is intended 1. To explain the different concepts used in sampling. 2. To explain how to conduct sampling surveys. 3. To make aware of the different Statistical Organizations and its functions. 4. To estimate expectation & variance in case of variables & attributes. 5. To estimate the sample size.		
Learning Outcome: After the successful completion of the module, the learner will be able to: 1. Distinguish between simple random sampling with and without replacement. 2. Understand the nature of work carried out in the different Statistical Organisations. 3. Prepare a questionnaire for sampling & census survey. 4. Estimate the mean and variance of the population values.		
1.1	Introduction to Design of Sample Surveys.	[6L]
	Types of Data: Primary & Secondary Data Methods for collection of data: Direct & Indirect Method, Questionnaire, Scheduling, Interview, E-survey (Google forms), Merits & Demerits.	

	Basic definitions: Population, Population unit, Sample, Sample unit, Parameter, Statistic, Estimator, Bias, Unbiasedness, Mean square error, Relationship between MSE & Variance, Standard error. Survey: Census survey, Sample Survey. Steps in conducting a sample survey with examples on designing appropriate Questionnaires. Errors: Concepts of Sampling and Non-sampling errors. Recognised Institutes: NSSO, CSO, IIPS and their functions. Types of Sampling: Probability and Non Probability sampling.	
1.2	**Simple Random Sampling: (SRS for variables).**	**[5L]**
	Definition: Sampling with & without replacement for variables (WR/WOR). Methods to select Simple random sample: Lottery method & use of Random numbers to select Simple random sample. Estimation: Population mean & total. Expectation & Variance of the Estimators, Unbiased Estimator of variance of these estimators. (WR/WOR). Sample Size: Estimation of Sample size based on a desired accuracy in case of SRS for variables (WR/WOR).	
1.3	**Simple Random Sampling: (SRS for attributes).**	[3L]
	Estimation of population proportion. Expectation & Variance of the estimators, Unbiased estimator of variance of these estimators. (WR/WOR). Sample Size: Estimation of Sample size based on a desired accuracy in case of SRS for attributes. (WR/WOR).	

References:

- Sampling Techniques: W.G. Cochran; 3rd Edition; Wiley (1978)
- Sampling Theory and methods: M.N. Murthy; Statistical Publishing Society. (1967)
- Sampling Theory: Des Raj; McGraw Hill Series in Probability and Statistics. (1968).

- Sampling Theory of Surveys with Applications: P.V. Sukhatme and B.V. Sukhatme; 3rd Edition; Iowa State University Press (1984).
- Fundamentals of Applied Statistics: S. C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand And Sons (2001).
- Theory and Analysis of Sample Survey Designs: Daroga Singh, F.S.Chaudhary, Wiley Eastern Ltd. (1986).
- Sampling Theory and Methods: S. Sampath, Second Edition (2005), Narosa.
- Theory and Methods of Survey Sampling: Parimal Mukhopadhyay, (1998), Prentice Hall of India Pvt. Ltd.

Module 2	Stratified Random Sampling, Cluster sampling, Two-stage and Multistage sampling	[12L]

Learning Objectives:

The module is intended

1. To explain the difference between Stratified & Cluster Sampling and situations where such methods will be suitable.

Learning Outcome:

After the successful completion of the module, the learner will be able to:

1. Distinguish between Stratified & Cluster Sampling
2. Estimate the sample size in case of proportional & optimum allocation.
3. Find efficiency of Stratified & Cluster Sampling over Simple Random Sampling.

2.1	Stratified Random Sampling.	[9L]
	Concept: Need for Stratification of population with suitable examples. Definition of Stratified Sample. Advantages of stratified Sampling. Estimation: Population mean & total in case of Stratified Random Sampling, Variance of the Unbiased Estimators, Unbiased Estimators of variances of these estimators. Allocation: Proportional allocation, Optimum allocation with and without varying costs. Efficiency: Comparison of Simple Random Sampling, Stratified Random Sampling using Proportional allocation & Neyman allocation.	

2.2	**Cluster Sampling.**	[2L]
	Estimation: Population Mean & total, Expectation of the estimators in Cluster Sampling with equal cluster sizes.	
2.3	**Two-Stage Sampling & Multi-Stage Sampling**	[1L]
	Concept only. Difference between stratification & multi-stage sampling.	

References:

- Sampling Techniques: W.G. Cochran; 3rd Edition; Wiley (1978)
- Sampling Theory and methods: M.N. Murthy; Statistical Publishing Society. (1967)
- Sampling Theory: Des Raj; McGraw Hill Series in Probability and Statistics. (1968).
- Sampling Theory of Surveys with Applications: P.V. Sukhatme and B.V. Sukhatme; 3rd Edition; Iowa State University Press (1984).
- Fundamentals of Applied Statistics: S. C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand And Sons (2001).
- Theory and Analysis of Sample Survey Designs: Daroga Singh, F.S.Chaudhary, Wiley Eastern Ltd. (1986).
- Sampling Theory and Methods: S. Sampath, Second Edition (2005), Narosa.
- Theory and Methods of Survey Sampling: Parimal Mukhopadhyay, (1998), Prentice Hall of India Pvt. Ltd.

Module 3	Ratio, Regression and Systematic sampling	[10L]

Learning Objectives:

The module is intended

1. To help improve the estimates using methods of Ratio & Regression.
2. To obtain a sample using systematic sampling.

Learning Outcome:

After the successful completion of the module, the learner will be able to:

1. To estimate the population parameters with increased precision.
2. To apply systematic sampling in suitable situations.
3. Compare the different sampling techniques.

3.1	**Ratio Estimation assuming SRSWOR.**	[3L]
	Concept & Estimation: Ratio Estimators for population Ratio, Mean & Total. Expectation & MSE of the Estimators. Estimators of MSE. Uses of Ratio Estimator.	

3.2	**Regression Estimation assuming SRSWOR**	[4L]
	Concept & Estimation: Regression Estimators for population Mean & Total. Expectation & Variance of the Estimators assuming known value of regression coefficient 'b'. Estimation of 'b'. Resulting variance of the estimators. Uses of regression Estimator. Efficiency: Comparison of Ratio, Regression & mean per Unit estimators.	
3.3	**Systematic Sampling.**	[3L]
	Systematic Sampling Procedure. Notations and Terminology. Variance of the estimated mean. Comparison of SRS & Stratified Sampling with Systematic Sampling. Introduction to Circular Systematic Sampling.	

References:

- Sampling Techniques: W.G. Cochran; 3rd Edition; Wiley (1978)
- Sampling Theory and methods: M.N. Murthy; Statistical Publishing Society. (1967)
- Sampling Theory: Des Raj; McGraw Hill Series in Probability and Statistics. (1968).
- Sampling Theory of Surveys with Applications: P.V. Sukhatme and B.V. Sukhatme; 3rd Edition; Iowa State University Press (1984).
- Fundamentals of Applied Statistics: S. C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand And Sons (2001).
- Theory and Analysis of Sample Survey Designs: Daroga Singh, F.S.Chaudhary, Wiley Eastern Ltd. (1986).
- Sampling Theory and Methods: S. Sampath, Second Edition (2005), Narosa.
- Theory and Methods of Survey Sampling: Parimal Mukhopadhyay, (1998), Prentice Hall of India Pvt. Ltd.

Question Paper Template

S.Y. B. Sc. (STATISTICS) SEMESTER III

Core Course- II

COURSE TITLE:Sampling Techniques

COURSE CODE:22US3STCC2SAT [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	14	10	6	-	-	-	30
II	12	14	2	-	2	-	30
III	10	12	2	4	-	2	30
Total marks per objective	36	36	10	4	2	2	90
% Weightage	40	40	11	4	2	2	100

S.Y. B. Sc. (STATISTICS) SEMESTER III
Core course - III
COURSE TITLE: Operations Research-I
COURSE CODE: 22US3STCC3OPRI [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Construct a mathematical model of real-world problems. 2. Explain basic concepts in LPP. 3. Solve LPP using graphical, simplex and Big M methods. 4. Construct dual and obtain a solution to primal / dual by solving the other. 5. Explain basic concepts in Transportation and Assignment Problem. 6. Identify optimum solution to Transportation and Assignment Problem. 7. Establish the optimum sequence for a series of jobs. 8. Solve two person zero sum game. 9. Simplify games of higher dimensions by reducing it to 2 X 2 matrix.

Module I	Linear programming problem	[14L]

Learning Objectives:
The module is intended to
1. Understand LPP
2. Formulate LPP mathematically.
3. Find optimum solution to LPP

Learning Outcomes:
After the successful completion of the module, the learner will be able to:
1. Construct a mathematical model of real-world problems.
2. Explain basic concepts in LPP.
3. Solve LPP using graphical, simplex and Big M methods.
4. Construct dual and obtain a solution to primal / dual.

1.1	Linear Programming Problem : Definition of LPP, Mathematical Formulation of LPP, Concepts of Solution, Feasible Solution, Basic Feasible Solution, Degenerate solution, Non-degenerate solution, Optimal solution, slack variable, Standard form of LPP	[4L]
1.2	Graphical Solution for problems with two variables, Simplex method of solving problems with two or more variables. Big M method.	[7L]
1.3	Concept of Duality, Its use in solving L.P.P. Relationship between optimum solutions to Primal and Dual. Economic interpretation of Dual.	[3L]
	References : • Operations Research: Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons. (1980) • Mathematical Models in Operations Research: J K Sharma, Tata McGraw Hill Publishing Company Ltd.(1989) • Operations Research: S.D.Sharma.11th edition, KedarNath Ram Nath& Company.(2001) • Operations Research: H. A.Taha.6th edition, Prentice Hall of India.8th edition (2008) • Quantitative Techniques for Managerial Decisions: J.K.Sharma, (2001), MacMillan India ltd.	
Module 2	**Transportation and Assignment Problem**	**[14L]**
Learning Objectives: The module is intended to 1. Understand problems in Transportation and Assignment. 2. Mathematical formulation TP and AP 3. Methods of finding optimum solution to TP and AP		

Learning Outcomes:
After the successful completion of the module, the learner will be able to:

1. Explain Transportation and Assignment Problem.
2. Identify optimum solution to Transportation and Assignment Problem.

2.1	Transportation Problem: Concept, Mathematical Formulation, Concepts of Solution, Feasible Solution, Balanced and Unbalanced Transportation Problem.	[4L]
2.2	Initial Basic Feasible Solution by North-West Corner Rule, Matrix Minima Method, Vogel's Approximation Method. Optimal Solution by MODI Method Problems involving unique solution, multiple solutions, degeneracy, maximization, prohibited route(s)	[4L]
2.3	Assignment Problem: Concept, Mathematical Formulation Balanced and unbalanced problem, relation with T.P. Solution by: Complete Enumeration Method and Hungarian method. Maximization type Assignment problems. Problems involving Prohibited routes. Travelling Salesman Problem.	[6L]
	References: • Operations Research: Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons. (1980) • Mathematical Models in Operations Research: J K Sharma, Tata McGraw Hill Publishing Company Ltd.(1989) • Operations Research: S.D.Sharma.11th edition, KedarNath Ram Nath& Company.(2001) • Operations Research: H. A.Taha.6th edition, Prentice Hall of India.8th edition (2008) • Quantitative Techniques for Managerial Decisions: J.K.Sharma, (2001), MacMillan India ltd.	

Module 3	Sequencing Problem and Game Theory	[8L]

Learning Objectives:

The module is intended to

1. Understand sequencing problem and find solution for the same.
2. Solve two person zero sum game.

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

1. Establish the optimum sequence for a series of jobs.
2. Solve two person zero sum game.
3. Simplify games of higher dimensions by reducing it to 2 X 2 matrix.

3.1	Sequencing Problem: Introduction, Assumptions, Johnsons algorithm for processing n Jobs through 2 and 3 Machines, Examples.	[3L]
3.2	Game Theory : Definitions of two persons Zero Sum Game , Saddle point, value of the game, Pure and Mixed strategy, Optimal solution of two person zero sum games, Dominance property, Derivation of formulae for (2X2) game. Graphical solution of (2Xn) and (mX2) games, Reduction of game theory to LPP.	[5L]

References:

- Operations Research: Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons. (1980)
- Mathematical Models in Operations Research: J K Sharma, Tata McGraw Hill Publishing Company Ltd.(1989)
- Operations Research: S.D.Sharma.11th edition, KedarNath Ram Nath& Company.(2001)
- Operations Research: H. A.Taha.6th edition, Prentice Hall of India.8th edition (2008)
- Quantitative Techniques for Managerial Decisions: J.K.Sharma, (2001), MacMillan India ltd.

Question Paper Template

S.Y. B. Sc. (STATISTICS) SEMESTER III

Core Course- III

COURSE TITLE:

COURSE CODE: [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I							30
II							30
III							30
Total marks per objective							90
% Weightage							100

S.Y. B. Sc. (STATISTICS) SEMESTER IV

Core course - I

COURSE TITLE: Probability and Sampling Distributions

COURSE CODE: 22US4STCCIPSD [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Derive statistical measures of various continuous probability distributions. 2. Apply the Central Limit Theorem. 3. Identify and derive the relationships between various probability distributions. 4. Apply appropriate test based on chi-square, t and F probability distributions. 5. Construct confidence intervals for the population parameters.

Module 1	Rectangular, Normal, Beta Distribution Type(I, II)	[12L]
Learning Objectives: This module is intended to 1. To know the most widely used continuous probability distributions such as rectangular, normal, beta type I and II, gamma 2. Recognize the importance of the central limit theorem and understand when it is appropriate to use normal approximations for the distribution of a statistic		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. A student will be able to understand the relationship between various transformations of the random variables following normal, beta type I and II, gamma 2. A student will be able to apply Central Limit Theorem to the suitable situation		
1.1	**Rectangular Distribution**	[1L]
	Definition, MGF, mean, variance	
1.2	**Normal Distribution**	[6L]
	Definition, MGF, CGF, Mean, Median, Mode, Standard deviation, MGF , CGF , Moments & Cumulants (up to fourth order), odd and even ordered central moments, skewness & kurtosis, Mean absolute deviation,	

	distribution of linear function of independent Normal variables. Fitting of Normal Distribution.	
1.3	**Central Limit Theorem for i.i.d. random variables with proof**	[1L]
1.4	**Beta Distribution of Type I**	[1L]
	Definition, raw moments, mean, variance, mode	
1.5	**Beta Distribution of Type II**	[3L]
	Definition, raw moments, mean, variance, mode, inter-relations between beta type I and type II distributions.	

References:

- Introduction to the theory of statistics: A. M. Mood, F.A. Graybill, D. C. Boyes, Third Edition; McGraw-Hill Book Company.
- Introduction to Mathematical Statistics: R.V.Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.
- John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
- Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.
- Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.
- Mathematical Statistics: J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.
- An Outline of Statistical Theory Vol. I: A.M. Goon, M.K. Gupta, B. DasGupta; Third Edition; TheWorldPress Pvt. Ltd.
- Statistical Methods Using R Software :V. R. Pawagi and Saroj A. Ranade ;Nirali Publications.
- Statistics Using R. S. G. Purohit, S. D. Gore, and S. R. Deshmukh. Narosa Publishing House.

Module 2	Exponential, Gamma, Chi-square Distribution	[12L]

Learning Objectives:

This module is intended to

1. To learn the various forms of the exponential, Gamma and chi-square distributions
2. To learn various applications of chi square distribution

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. A student will be able to relate the exponential, Gamma and chi square distribution by changing the parameters appropriately
2. A student will be able to apply chi square test

2.1	**Exponential Distribution**	[2L]
	Definition, moments, MGF, CGF, mean, mode, variance, skewness and kurtosis, Median, Quartiles, Deciles, Percentiles memory less property	
2.2	**Gamma Distribution (with Single & Double parameter)**	[4L]
	Definition, raw moments, mean, variance, mode, MGF, CGF, skewness and kurtosis, Distribution of X+Y, X/Y, X/ (X + Y)	
2.3	**Chi-Square Distribution**	[3L]
	Definition, Concept of degrees of freedom. Mean, Median, Mode, variance, MGF, CGF, additive property, Sampling distributions of sample mean and sample variance and their independence for a sample drawn from Normal distribution, distribution of U / V, U / (U+V) where U and Y are independent chi square variates.	
2.4	**Applications of Chi-Square**	[3L]
	Confidence interval for the variance of a Normal population, Test of significance for specified value of variance of a Normal population. Test for goodness of fit, Test for independence of attributes.	

References:

- Introduction to the theory of statistics: A. M. Mood, F.A. Graybill, D. C. Boyes, Third Edition; McGraw-Hill Book Company.
- Introduction to Mathematical Statistics: R.V.Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.
- John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.

- Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.
- Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.
- Mathematical Statistics: J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.
- An Outline of Statistical Theory Vol. I: A.M. Goon, M.K. Gupta, B. DasGupta; Third Edition; TheWorldPress Pvt. Ltd.
- Statistical Methods Using R Software :V. R. Pawagi and Saroj A. Ranade ;Nirali Publications.
- Statistics Using R. S. G. Purohit, S. D. Gore, and S. R. Deshmukh. Narosa Publishing House.

Module 3	t-distribution and F distribution	[12L]

Learning Objectives:

The module is intended to

1. To learn probability distribution of t and F variate
2. To learn various applications of t and F distributions

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. A student will be able to apply t and F distributions as per the demand of the problem

3.1	**t-Distribution**	[3L]
	Definition, derivation, Mean, Median, Mode, variance, MGF, CGF, odd and even ordered central moments, asymptotic properties, Student's t	
3.2	**Applications of t**	[3L]
	Confidence interval for: Mean of Normal population, difference between means of two independent Normal populations having the same variance, test of significance of: mean of a Normal population, difference in means of two Normal populations based on independent sample s with equal variances.	
3.3	**F-Distribution**	[4L]
	Definition, derivation of the distribution, MGF, CGF, Mean, Mode, variance. Distribution of: Reciprocal of an	

	F variate. Interrelationship of F with: t-distribution, Chi-square distribution & Normal distribution	
3.4	**Applications of F**	[2L]
	Confidence interval for ratio of variances of two independent Normal populations, Test for equality of variances of two independent Normal populations	

References:

- Introduction to the theory of statistics: A. M. Mood, F.A. Graybill, D. C. Boyes, Third Edition; McGraw-Hill Book Company.
- Introduction to Mathematical Statistics: R.V.Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.
- John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
- Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.
- Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.
- Mathematical Statistics: J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.
- An Outline of Statistical Theory Vol. I: A.M. Goon, M.K. Gupta, B. DasGupta; Third Edition; TheWorldPress Pvt. Ltd.
- Statistical Methods Using R Software :V. R. Pawagi and Saroj A. Ranade ;Nirali Publications.
- Statistics Using R. S. G. Purohit, S. D. Gore, and S. R. Deshmukh. Narosa Publishing House.

Question Paper Template

S.Y. B. Sc. (STATISTICS) SEMESTER IV

Core Course- I

COURSE TITLE: Probability and Sampling Distributions

COURSE CODE: 22US4STCCIPSD [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	6	8	4	4	8	-	30
II	6	6	12	2	4	-	30
III	4	4	12	4	6	-	30
Total marks per objective	16	18	28	10	18	-	90
% Weightage	18	20	31	11	20	-	100

S.Y. B. Sc. (STATISTICS) SEMESTER IV

Core course - II

COURSE TITLE: Design of Experiments-I

COURSE CODE: 22US4STCC2DOE1 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1. Formulate the appropriate model in case of one-way, two-way and three-way classification. 2. List the assumptions and hypotheses to be tested for the given model. 3. Estimate the parameters of the model and the various sums of squares. 4. Find the expectation of various sums of squares and the variance of the estimators. 5. Analyse the significance of the different effects due to rows, columns or treatments. 6. Explain & distinguish between the concepts used in designs of experiments. 7. Identify the design & explain the principles used. 8. Compare the efficiency of one design over another. 9. Estimate the missing value and analyse the design.

Module 1	Introduction to ANOVA-One way and Two way classification	[12L]
Learning Objectives: The module is intended 1. To discuss the concept of fixed effect model with respect to one-way and two-way classification.		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Distinguish between fixed effect & random effect model. 2. Analyse the significance of the factors in case of one-way & two-way classification. 3. Estimate the parameters, various sum of squares, expectation of various sum of squares & variance of the estimators.		
1.1	Introduction to Analysis of Variance	[2L]
	Introduction: Use of analysis of variance, Cochran's Theorem. Fixed effect, Random effect model and mixed effect model.	

1.2	**Analysis of variance One-way classification (Fixed Effect Model).**	[5L]
	Concept: One way classification with equal & unequal observations per class, Mathematical Model, Assumptions, Hypothesis to be tested. Estimation: Least square estimators of the parameters, Various Sum of Squares, Expectation of various sums of squares, Variance of the estimators Construction of ANOVA table. Post Analysis: Concept of Contrast, S.E., Critical Difference & C.I.	
1.3	**Analysis of variance Two-way classification (Fixed Effect Model).**	[5L]
	Concept: Two-way classification with one observation per cell. Mathematical Model, Assumptions, Hypothesis to be tested. Estimation: Least square estimators of the parameters, Various Sum of Squares, Expectation of various sums of squares, Variance of the Estimators Analysis: F-test, Analysis of variance table. Post Analysis: Critical Difference.	

References:

- Experimental Designs: W.G. Cochran and G.M.Cox; Second Edition;John Wiley and Sons.
- The Design and Analysis of Experiments: Oscar Kempthorne, John Wiley and Sons.
- Design and Analysis of Experiments: Douglas C Montgomery; 6th Edition; John Wiley & Sons.
- Design and Analysis of Experiments: M.N.Das and N.C.Giri, 2nd Edition; New Age International (P) Limited;1986.
- Experimental Design, Theory and Application: Walter T Federer; Oxford & IBH Publishing Co. Pvt. Ltd.
- Fundamentals of Applied Statistics: S.C.Gupta and V.K.Kapoor; 3rd Edition; Sultan Chand and Sons (2001).
- Statistical Principles in Experimental Design: B.J. Winer, McGraw Hill Book Company.

Module 2	Introduction to designs of experiment, CRD, RBD, BIBD	[12L]
Learning Objectives: The module is intended 1. To explain the various concepts & principles in experimental designs.		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Understand the terminologies used in the designs of experiments. 2. Apply the different designs in suitable situations. 3. Estimate the missing values. 4. Compare the efficiency of one design over other.		
2.1	**Introduction to Design of Experiments.**	[3L]
	Concepts: Experiments, Experimental unit, Treatment, Yield, Block, Replicate, Experimental Error, Precision. Principles of Design of Experiments: Replication, Randomization & Local Control. Choice of size, shape of plots & blocks in agricultural & non-agricultural experiments. Efficiency of design DI with respect to design D2.	
2.2	**Completely Randomized Design (CRD)**	[3L]
	Concept of C.R.D.: Mathematical Model, Assumptions, Hypothesis to be tested. Estimation: Least square estimators of the parameters, Expectation of various sums of squares, Variance of the estimators Analysis :F-test, Analysis of variance table.	
2.3	**Randomized Block Design (RBD).**	[3L]
	Concept of R.B.D.: Mathematical Model, Assumptions, Hypothesis to be tested. Estimation: Least square estimators of the parameters, Expectation of various sums of squares, Variance of the estimators Analysis: F-test, Analysis of variance table. Efficiency: RBD relative to a CRD. Missing plot technique: One missing observation in case of RBD.	

2.4	Balanced Incomplete Block Design (BIBD).	[3L]
	Concept: Parameters of BIBD, Incidence Matrix, Parametric relations Symmetry: Necessary & Sufficient Condition, Theorem. Resolvable BIBD & Affine Resolvable BIBD.	

References:

- Experimental Designs: W.G. Cochran and G.M.Cox; Second Edition;John Wiley and Sons.
- The Design and Analysis of Experiments: Oscar Kempthorne, John Wiley and Sons.
- Design and Analysis of Experiments: Douglas C Montgomery; 6th Edition; John Wiley & Sons.
- Design and Analysis of Experiments: M.N.Das and N.C.Giri, 2nd Edition; New Age International (P) Limited;1986.
- Experimental Design, Theory and Application: Walter T Federer; Oxford & IBH Publishing Co. Pvt. Ltd.
- Fundamentals of Applied Statistics: S.C.Gupta and V.K.Kapoor; 3rd Edition; Sultan Chand and Sons (2001).
- Statistical Principles in Experimental Design: B.J. Winer, McGraw Hill Book Company.

Module 3	LSD & Factorial experiments	[12L]

Learning Objectives:

The module is intended

1. To explore the general theory of factorial designs and its applications.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Differentiate between block designs & factorial designs.
2. Estimate the parameters in case of multiway classification.
3. Calculate the various treatment effects.

3.1	Latin Square Design (LSD).	[6L]
	Concept of C.R.D.: Mathematical Model, Assumptions, Hypothesis to be tested. Estimation: Least square estimators of the parameters, Expectation of various sums of squares, Variance of the estimators Analysis: F-test, Analysis of variance table.	

	Efficiency: Efficiency of the design relative to RBD, CRD. Missing plot technique: One missing observation in case of LSD.	
3.2	**Factorial Experiments.**	**[6L]**
	Concept: Definition, Purpose & Advantages. 2^k Experiments:2^2, 2^3 Experiments. Calculation of Main & interaction Effects. Yates' method. Analysis: Analysis of 2^2& 2^3 factorial experiments in RBD & LSD.	

References:

- Experimental Designs: W.G. Cochran and G.M.Cox; Second Edition;John Wiley and Sons.
- The Design and Analysis of Experiments: Oscar Kempthorne, John Wiley and Sons.
- Design and Analysis of Experiments: Douglas C Montgomery; 6th Edition; John Wiley & Sons.
- Design and Analysis of Experiments: M.N.Das and N.C.Giri, 2nd Edition; New Age International (P) Limited;1986.
- Experimental Design, Theory and Application: Walter T Federer; Oxford & IBH Publishing Co. Pvt. Ltd.
- Fundamentals of Applied Statistics: S.C.Gupta and V.K.Kapoor; 3rd Edition; Sultan Chand and Sons (2001).
- Statistical Principles in Experimental Design: B.J. Winer, McGraw Hill Book Company.

Question Paper Template

S.Y. B. Sc. (STATISTICS) SEMESTER IV

Core Course- II

COURSE TITLE:Design of Experiments-I

COURSE CODE:22US4STCC2DOE1 [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	10	12	8	-	-	-	30
II	12	12	2	2	2	-	30
III	8	8	8	-	2	2	30
Total marks per objective	30	32	18	2	4	2	90
% Weightage	33	36	20	2	4	2	100

S.Y. B. Sc. (STATISTICS) SEMESTER IV
Core course - III
COURSE TITLE: Project Management and Industrial Statistics
COURSE CODE: 22US4STCC3PRM [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Construct simple network diagrams and apply the techniques of PERT, CPM in Project Management. 1. Determine the critical path and the project completion time. 2. Carry out updating in the project networks. 3. Apply the concept of crashing of activities and solve simple problems. 4. Apply the seven process control tools to investigate drift. 5. Construct control charts for variables and attributes to determine if the process is in statistical control or not. 6. Explain concept of six sigma. 7. Evaluate efficiency of the process using process capability indices. 8. Explain the role of acceptance sampling in quality control. 10. Apply various acceptance sampling plans to accept or reject lots.

Module 1	PERT and CPM	[14L]

Learning Objectives:
The module is intended

1. Understand the need of planning and scheduling, network analysis in project management
2. Construct a network diagram.
3. Analyze deterministic and nondeterministic networks using CPM and PERT techniques.
4. Describe the Crashing of activities and solve simple problems.

Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Construct network for the project 2. Develop abilities in project evaluation technique like CPM and PERT 3. Estimate the duration of a project 4. Carry out updating in project 5. Solve problems involving costs.		
1.1 1.2	Introduction, Basic concepts of network analysis Definitions: Activity, Event, Dummy activity, Predecessor and successor activities and events. Rules for drawing network, Fulkerson's Rule. Bar Diagram (Gantt Chart) and Network Diagram. Slack time and Float times. Critical path Method (CPM), Project evaluation review technique (PERT), Updating	[2L] [8L] [4L]
1.3	• Project cost analysis	
	• References: • PERT and CPM, Principles and Applications: Srinath. 2nd edition, East-west press Pvt. Ltd. (1975) • Operations Research: Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons. (1980) • Mathematical Models in Operations Research : J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd. • Operations Research: S.D.Sharma.11th edition, KedarNath Ram Nath& Company. (2001)	
Module 2	**Statistical Process Control**	**[12L]**
Learning Objectives: The module is intended to 1. Understand statistical process control. 2. Decide whether process is in statistical control.		

Learning Outcomes:
After the successful completion of the module, the learner will be able to:

1. Apply the seven process control tools to investigate drift.
2. Construct control charts for variables and attributes.
3. Determine if the process is in statistical control or not.
4. Explain the concept of six sigma.
5. Evaluate efficiency of the process using process capability indices.

2.1	Introduction to SPC: Meaning and purpose of Statistical Process Control(SPC). Meaning of quality of a product and quality improvement, need of Process control. On line process control methods (control charts) and offline process control methods (Sampling schemes and plans) as lot control method	[1L]
2.2	Seven Process Control Tools: (i) Check Sheet (ii) Cause and effect diagram (CED) (iii) Pareto Diagram (iv) Histogram (v) Control Chart (vi) Scatter Diagram (vii) Design of Experiments (DOE).	[2L]
2.3	Control Charts : Chance causes and assignable causes of quality variation. Criteria for detecting lack of control situations. Construction and working of control charts. Control charts for variables : Construction and working Control charts for mean, control charts for range (R). Control charts for attributes : Construction and working of p charts for fixed and variable sample size. np, c and u control charts for fixed sample size.	[6L]
2.4	Choice between attributes and variable control charts Guidelines for implementing control charts	[1]
2.5	Process Capability Analysis using capability ratios: Use and interpretation C_p, C_{pk}, C_{pm} Confidence interval on process capability ratio C_p, C_{pk}	[1]

2.6	• Introduction to six sigma methodology.	[1]
	References: • Operations Research: Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons. (1980) • Mathematical Models in Operations Research : J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd. • Operations Research: S.D.Sharma.11th edition, KedarNath Ram Nath& Company. (2001) • Introduction to Statistical Quality Control: D.C. Montgomery, 6th edition, John Willey and Sons (2009) • Statistical Quality Control: E.L.Grant. 2nd edition, McGraw Hill, (2000) • Quality Control and Industrial Statistics: Duncan. 3rd edition, D.Taraporewala sons & company. (1970) • Quality Control: Theory and Applications: Bertrand L. Hansen, Prentice Hall of IndiaPvt. Ltd.(1973)	
Module 3	Acceptance Sampling	[10L]
Learning Objectives: The module is intended 1. Understand the sampling inspection plans. 2. Apply Sampling Inspection Plans.		
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Explain the role of acceptance sampling in quality control. 2. Apply acceptance sampling plans to accept or reject sampling lots.		

3.1	Introduction to Acceptance sampling plan for Attributes: Concept of sampling inspection plan, comparison between 100% inspection and sampling inspection. Lot formation. Explanation of the terms: Producer's risk. Consumer's risk, Acceptable Quality Level (AQL). Lot Tolerance Fraction Defective (LTFD), Average Outgoing Quality (AOQ), Average Outgoing Quality Limit (AOQL), Average Sample Number (ASN), Average Total Inspection (ATI), Operating characteristic (OC) curve, AOQ curve.	[3L]
3.2	Single Sampling Plan: Evaluation of probability of acceptance using (i) Hypergeometric (ii) Binomial (iii) Poisson distributions. Operating Characteristics (OC) curve. Derivation of AOQ and ATI. Graphical determination of AOQL, determination of a single sampling plan	[3L]
3.3	Double Sampling Plan : Evaluation of probability of acceptance. Operating Characteristics (OC) curve. Derivation of AOQ, ASN and ATI (with complete inspection of second sample). Comparison of single sampling plan and double sample plan.	[2L]
3.4	Introduction to Multiple sampling plan and sequential sampling plan.	[1L]

References:

- Operations Research: Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons. (1980)
- Mathematical Models in Operations Research : J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.
- Operations Research: S.D.Sharma.11th edition, KedarNath Ram Nath& Company. (2001)
- Introduction to Statistical Quality Control: D.C. Montgomery, 6th edition, John Willey and Sons (2009)
- Statistical Quality Control: E.L.Grant. 2nd edition, McGraw Hill, (2000)
- Quality Control and Industrial Statistics: Duncan. 3rd edition, D.Taraporewala sons & company. (1970)
- Quality Control: Theory and Applications: Bertrand L. Hansen, Prentice Hall of IndiaPvt. Ltd.(1973)

Question Paper Template
S.Y. B. Sc. (STATISTICS) SEMESTER IV
Core Course- III
COURSE TITLE: Project Management and Industrial Statistics
COURSE CODE: [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I							30
II							30
III							30
Total marks per objective							90
% Weightage							100