Shri Vile Parle Kelavani Mandal's

MITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBEN JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)

NAAC Reaccredited 'A' grade, CGPA: 3.57,
Granted under RUSA, FIST-DST & Star College Scheme of DBT, Government of India,
Best College (2016-17), University of Mumbai

Affiliated to the
UNIVERSITY OF MUMBAI

Program: B.Sc.- Statistics

S. Y. B. Sc.

Semester III & IV

Choice Based Credit System (CBCS) with effect from the Academic year 2022-23 (Revised)

A.C. No: 12
Agenda No: 4 (xiv)

PREAMBLE

In the first year, students were taught – methods of data representation and summarization, Correlation and regression which are the tools that are frequently used in statistical analysis. Further they are introduced to probability, the concept of random variables-discrete as well as continuous and different discrete probability distributions along with applications. Relevant problems on these topics will be included in practical course. Thus, student who takes up the subject of Statistics is prepared to learn the advanced studies in Statistics.

In the second year of under-graduation, the learner will be expected to study various probability distributions and their applications to real life situations. An important branch of Statistics, Sampling theory and Design of Experiments will be introduced, where sampling methods and designs used in agriculture and industry will be studied. Papers of applied Statistics, like Industrial Statistics will also be studied

The 3 courses of theory and practicals for Semester-III & Semester-IV respectively are compulsory to all students offering Statistics at second year.

The courses are as follows: -

Semester III : USMAST301 : DISTRIBUTION THEORY I
USMAST302 : SAMPLING THEORY
USMAST303 : APPLIED STATISTICS 1: INDUSTRIAL STATISTICS

Semester IV : USMAST401 : DISTRIBUTION THEORY II
USMAST402 : ANALYSIS OF VARIANCE &
DESIGN OF EXPERIMENTS
USMAST403 : APPLIED STATISTICS 2: (Vital Statistics, Simulation, Reliability**)**

I profusely thank all committee members for their efforts in drafting the syllabus.

N.B.-

(i) The duration of each theory lecture will be of 1 hour. A course consists of 3 units. For each unit the number of hours allotted are 10. The total number of hours for each course will thus be 30.

(ii) There will be one practical per batch for each course. The duration of each practical will be of 2 hours. For practical component the value of One Credit is equal to 30 learning hours.

(iii) Thus in a week, a student will study 6 hours of theory and 6 hours of Practicals.

Evaluation Pattern for theory papers

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester End Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester End Examinations is as shown below:

a) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	Test / Assignment	60%
Component 2 (CA-2)	Test / Assignment	40%

b) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	Description	Marks / Sub Question	Total Marks
Q1 to Q3	Attempt Any Three sub questions out of Four sub questions.	7	21 Marks. 21 x 3 = 63 Marks
Q4	Attempt Any three sub questions (out of Four sub questions)	4	12
		Total Marks	**75**

Evaluation Pattern for practical papers

In the Practical Exams, there will be 20% assessment for journal and laboratory work and 80% as term end component to be conducted as a semester end exam per course. For each course there will be one examiner per batch who will assess the practical examination answer books.

Signature
HOD

Signature
Approved by Vice-Principal

Signature
Approved by Principal

Program: B.Sc.- Statistics			Semester : III
Course: DISTRIBUTION THEORY I			Course Code: USMAST301
Teaching Scheme		Evaluation Scheme	
Lecture (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
2	2 + 1 = 3	25%	75%

Learning Objectives:

Unit 1:

1. To learn the definition of a moment-generating function.
2. To find the moment-generating function of a binomial random variable.
3. To learn how to use a moment-generating function to find the mean and variance of a random variable.
4. To learn how to use a moment-generating function to identify which probability mass function a random variable X follows.
5. To understand the steps involved in each of the proofs in the lesson.
6. To be able to apply the methods learned in the lesson to new problems.

Unit 2:

1. Making use of joint probability mass function and joint probability density to calculate probabilities.
2. Calculate marginal and conditional pdf from joint probability distributions.
   Interpret and calculate covariance and correlations between random variables
   To derive the probability distributions of transformed variables

Unit 3:

1. This course gives an introduction to asymptotic methods in statistics.
2. Types of convergence such as convergence in probability, convergence withprobability one and convergence in distribution are discussed.
3. A version of the law of large numbers and the Lindeberg central limit theoremare proved.

Course Outcomes:

After completion of the course, learners would be able to:

(CO1: Remember)

i) Recall definitions of probability function, density function, cumulative distributionfunction and moment generating function, and their inter-relationships

ii)State p.m.f. and p.d.f. of various standard distributions and also their distribution function, skewness and kurtosis.

(CO2: Understand)

i) Determine and interpret independence and conditional distributions

ii) Recall well known distributions such as Bernoulli, binomial, Poisson, geometric, uniform.

iii)Understand which distribution is to be applied in different scenarios.

(CO3: Apply)

i) Use moment generating function to determine distribution function and moments

ii) Find distributions of functions of random variables, including distributions ofmaximum and

minimum observations

iii) Identify and apply appropriate distribution in case of various real life problems.

iv) Apply methods from algebra and calculus to derive the mean and variance for arange of probability distributions

(CO4: Analyse)

i) Distinguish between the different discrete and continuous distributions.

ii) The basics of asymptotic analysis in statistics andprobability

iii) Derive probability distributions relevant to functions of random variables

(CO5: Evaluate)

i) Calculate moments and moment generating function

ii) Calculate probabilities relevant to multivariate distributions, including marginaland conditional probabilities and the covariance of two random variables.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of hours**
1	Generating functions.	10 Hours
2	Bivariate Distributions & Transformation of Variables	10 Hours
3	Convergence in probability and Limit theorems	10 Hours
	Total	30 hours
Module	**DISTRIBUTION THEORY 1**	**No. of Hours/ Credits 30/2**
1	**Generating functions.**	**10**
	Univariate Random Variables (Discrete and Continuous): ❖ Moment Generating Function, Cumulant generating function-their important properties. ❖ Relationship between moments and cumulants and their uses. ❖ Characteristic Function- Its properties (without proof). ❖ Uniform, Bernoulli, Binomial, Poisson, Geometric, Negative Binomial & Hyper geometric distributions. ❖ The following aspects of the above distributions (wherever applicable) to be discussed: Moment Generating Function, Cumulant Generating Function, Additive property, Recurrence relation for central Moments, Skewness and Kurtosis (without proof), Limiting distributions. Fitting of Distributions. Truncated Binomial and Truncated Poisson Distribution: Suitable illustrations, probability mass function, mean.	2 1 2 3 2
2	**Bivariate Distributions & Transformation of Variables**	**10**
	❖ Joint Probability mass function for Discrete random variables. ❖ Joint Probability density function for continuous random variables. ❖ Their properties.	5

	❖ Marginal and conditional Distributions. ❖ Independence of Random Variables. ❖ Conditional Expectation & Variance. ❖ Regression Function. Coefficient of Correlation. ❖ Transformation of Random Variables and Jacobian of transformation with illustrations. ❖ Definition and properties of Moment Generating Function (MGF) of two random variables of discrete and continuous type. Necessary and Sufficient condition for independence of two random variables.	2 3
3	**Convergence in probability and Limit theorems**	**10**
	❖ Limit laws: Convergence in probability, almost sure convergence. ❖ Chebyshev's inequality - Convergence in probability and in distribution ❖ Convergence in distributions– Limit Laws Weak / Strong Law of Large Numbers ❖ Central limit theorem and its applications. ❖ Liapunov Theorem. ❖ DeMoivre - Laplace Limit Theorem. ❖ Lindeberg-Levy theorem.	5 5

Essential Readings:

1. S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistics: 8th,Sultan Chand & Sons.
2. R.V.Hogg, A.T. Craig, Introduction to Mathematical Statistics: Collier McMillanPublishers

Suggested Readings:

1. A. M. Mood, F.A. Graybill, D. C. Boyes, Introduction to the Theory of Statistics, 3rd Edition McGraw Hill Book Company
2. R.V.Hogg, E. A.Tannis, Probability and Statistical Inference, Collier McMillanPublishers
3. John E. Freund's I. Miller, M. Miller, Mathematical Statistics, 6th Edition, Pearson Education Inc.
4 P.G. Hoel, Introduction to Mathematical Statistics, 4th Edition,John Wiley &Sons Inc.
5. J. Medhi, Statistical Methods: An IntroductoryText: 2nd Edition;Wiley Eastern Ltd.
6. A.M. Goon, M.K. Gupta, B.DasGupta; An Outline of Statistical Theory Vol. 1: 3rd Edition; The World Press Pvt. Ltd.
7. Goon A.M., Gupta M.K.and Das Gupta B. (1986) : Fundamentals of Statistics, Vol. II, World Press,Calcutta.

Program: B.Sc.- Statistics			**Semester : III**
Course: SAMPLING THEORY			**Course Code: USMAST302**
Teaching Scheme		**Evaluation Scheme**	
Lecture (Hours per week)	**Credit**	**Continuous Assessment and Evaluation (CAE) (Marks - 25)**	**End Semester Examination (ESE) (Marks-75 in Question Paper)**
2	2	25%	75%

Learning Objectives:

Unit 1:

1. Define principal concepts about sampling. Lists the stages of sampling process
2. The ideas of census surveys and sample surveys.
3. Learn the reasons for sampling
4. Develop an understanding about different sampling methods
5. Discuss the relative advantages & disadvantages of each sampling methods

Unit 2:

To make the learner aware of when to use stratified sampling.

Unit 3:

1. To make the learner aware of Ratio & Regression Methods of Estimation and Systematic Sampling.
2. To make the learner aware of the Statistical agencies functioning in India.
3. To avoid nonresponse biases in estimates.

Course Outcomes:

After completion of the course, learners would be able to:

(CO1: Remember)

i) Define what is sampling and its concept.

(CO2: Understand)

i) Identify the advantages and disadvantages of sampling

ii) Describe sampling terminologies

iii) which sampling technique is to be applied in different scenarios.

(CO3: Apply)

i) Decide when to conduct a stratified sampling method.

ii) Decide when to conduct a cluster sampling method.

iii)Decide when to conduct a systematic sampling method.

iv) Apply all sampling methods in practical situation.

(CO4: Analyse)

i) Differentiate between probability sampling and non-probability sampling techniques.

(CO5: Evaluate)

i) Determine sample size and selection method;

ii) Compute estimates from stratified sample results.

iii) Compute estimates from cluster sampling results

iv) Compute estimates from systematic sample results.

Outline of Syllabus: (per session plan)		
Module	**Description**	**No of hours**
1	Sampling Concepts and Simple Random Sampling for Variables and Attributes.	10
2	Stratified Random Sampling.	10
3	Ratio and Regression methods. Concepts of Systematic, Cluster,Multiple Stage Sampling. Indian Statistical Agencies and their functions.	10
	Total	30
Module	**SAMPLING THEORY**	**No. of Hours/ Credits 30/2**
1	Sampling Concepts and Simple random Sampling for Variables and Attributes	10
	❖ Population, Population unit, Sample, Sample unit, Parameter, Statistic, Estimator,Bias, Unbiasedness, Mean square error & Standard error. ❖ Census survey, Sample Survey. Steps in conducting a sample survey withexamples on designing appropriate Questionnaire. ❖ Concepts of Sampling and Non-sampling errors. ❖ Concepts and methods of Probability and Non Probability sampling. Purposive Sampling, Quota sampling, Snowball sampling. ❖ Simple Random Sampling:(SRS). ❖ Definition, Sampling with & without replacement (WR/WOR). ❖ Lottery method & use of Random numbers to select Simple random sample. ❖ Estimation of population mean & total. Expectation & Variance of the estimators,Unbiased estimator of variance of these estimators. (WR/WOR). ❖ Estimation of population proportion. Expectation & Variance of the estimators,Unbiased estimator of variance of these estimators. (WR/WOR). ❖ Confidence interval for population mean/ proportion. (WR/WOR) Estimation of Sample size based on a desired accuracy in case of SRS for variables & attributes. (WR/WOR)	2 2 1 2 2 1
2	Stratified Random Sampling	10
	❖ Need for Stratification of population with suitable examples. Definition of Stratified Sample. Advantages of stratified Sampling. ❖ Estimation of population mean & total in case of Stratified Random	2 3

	Sampling (WOR within each strata). Expectation & Variance of the unbiased estimators, Unbiased estimators of variances of these estimators. ❖ Proportional allocation, Optimum allocation with and without varying costs. Comparison of Simple Random Sampling, Stratified Random Sampling using Proportional allocation & Neyman allocation.	3 2
3	Ratio And Regression methods. Concepts of Systematic, Cluster,Multiple Stage Sampling. Indian Statistical agencies and their functions	10
	❖ Ratio & Regression Methods of Estimation. ❖ Ratio Estimators for population Ratio, Mean & Total. Expectation & MSE of theEstimators. Estimators of MSE, Uses of Ratio Estimator. ❖ Regression Estimators for population Mean & Total. Expectation & Variance ofthe Estimators assuming known value of regression coefficient 'b'. ❖ Estimation of 'b'. Resulting variance of the estimators. Uses of regressionEstimator. Comparison of Ratio, Regression & mean per Unit estimators. ❖ Systematic Sampling: Concept and basic ideas of Cluster sampling, Two-stage sampling and Multi Stagesampling. NSSO, CSO and their functions. Concepts and methods of Probability and Non-Probability Sampling.	1 2 2 2 1 2

Essential Readings:

1. Cochran W.G (1977): Sampling Techniques, John Wiley and Sons, New York.
2. Parimal Mukhopadhyay,(1998), Theory and Methods of SurveySampling: Prentice Hall of India Pvt. Ltd.

Suggested Readings:

1. Des Raj (2000): Sample Survey Theory Narosa Publishing House, NewDelhi.
2. Daroga Singh,F.S.Chaudhary: Theory and Analysis of Sample Survey Designs: Wiley EasternLtd. (1986)
3. Sukhtme P.V., Sukhatme B.V., Sukhatme S. and Asok C. (1984) :Sampling Theory of Surveys withApplications, Indian Societyof AgriculturalStatistics, NewDelhi
4. P.V. Sukhatme and B.V.Sukhatme. Sampling Theory of Surveys withApplications:3rd Edition; Iowa State University Press (1984)
5. Murthy M.N. (1967): Sampling Theory and Methods, Statistical PublishingSociety, Calcutta.
6. Sampath S. (2000) :Sampling Theory and Methods, Narosa Publishing House, NewDelhi.
7. Hansen M.H., Hurwitz W.N. and Madow W.G. (1975) :Sample Survey Method and Theory
8. Kish L (1965): Survey Sampling, John Wiley and Sons,New York.

Program: B.Sc.- Statistics		Semester : III	
Course: Applied Statistics 1: Industrial Statistics		Course Code: USMAST303	
Teaching Scheme		Evaluation Scheme	
Lecture (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
2	2	25%	75%

Learning Objectives:

Unit 1:

1. Understand Common and Special Variations
2. Construct and Interpret Control Charts P-chart X-bar and R charts

Unit 2:

1. Exhibit a personal familiarity with the concepts and practices of Acceptance Sampling
2. State one or more advantages and disadvantages of Acceptance Sampling, and curve
3. Six sigma limits

Unit 3:

1. Understand the role and application of PERT/CPM for project scheduling.
2. Learn how to define a project in terms of activities such that a network can be used to describe the project.
3. Know how to compute the critical path and the project completion time.
4. Know how to convert optimistic, most probable, and pessimistic time estimatesinto expected activity time estimates.
5. With uncertain activity times, be able to compute the probability of the projectbeing completed by a specific time.
6. Understand the concept and need for crashing.
7. Learn how to schedule and control project costs with PERT/Cost

Course Outcomes:

After completion of the course, learners would be able to:

(CO1:Remember)

i) Define the average outgoing quality of inspected lots.

(CO2:Understand)

i) Explain the purpose of acceptance sampling.
ii) Describe project management objective.
iii) Describe the project life cycle

(CO3:Apply)

i) Construct the appropriate Quality Control charts and critically discuss the role of such charts in monitoring a process.
ii) Develop an appropriate quality assurance plan to assess the ability of the service tomeet its required national and international quality standard.
iii) Draw network diagram of various activities.

(CO4:Analyse)

i) Elucidate techniques and concepts of Statistical Quality Control, Quality Assurance, Performance Analysis and Multi stream process control.

ii) Compare and contrast single and multiple sampling plans.

(CO5: Evaluate)

i) Assess the ability of a process to meet customer expectations.

ii) Construct and use the operating characteristic curve.

iii) Estimate the completion time of a project.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Control Charts	10
2	Acceptance Sampling	10
3	CPM and PERT	10
	Total	**30**

Module	**Applied Statistics 1: Industrial Statistics**	**No. of Hours/ Credits 30/2**
1	Control Charts	**10**
	❖ Principles of control. Process quality control of attributes and variables. ❖ ($\bar{X}$, R), p, c, np charts, p-chart with variable sample size, their uses and applications. Problems involving setting up standards for future use.	1 7 2
2	Acceptance Sampling	**10**
	❖ Lot Acceptance Sampling Plans by Attributes: ❖ Single Sampling Plans (without curtailment). ❖ OC function and OC curves. AQL, LTPD, ASN, ATI, AOQ, Consumer's risk, Producer's risk. ❖ Double Sampling Plan (without curtailment). ❖ OC function and OC curves, AOQ, ASN and ATI. Introduction to Six sigma limits.	3 2 2 2 1
3	CPM and PERT	**10**
	❖ Objective and Outline of the techniques. Diagrammatic representation of activities in a project: Gantt Chart and Network Diagram. ❖ Slack time and Float times. Determination of Critical path. Probability consideration in project scheduling. Project cost analysis, Updating.	4 4 2

Essential Readings:

1. S. C. Gupta and V.K.Kapoor, Fundamentals of Applied Statistics;3rd Edition; Sultan Chand and Sons (2001).
2. E.L. Grant. Statistical Quality Control: 2nd edition,McGraw Hill,1988.
3. S.D.Sharma., Operations Research:.11th edition, KedarNath Ram Nath & Company.

SUGGESTED READINGS:

1. Duncan., Quality Control and Industrial Statistics, 3rd edition D. Taraporewal Sons & company
2. Bertrand L. Hansen, (1973) Quality Control: Theory and Applications: (1973), Prentice Hall of India Pvt. Ltd.
3. I.V. Burr, Mardekkar, Quality Control: New York, 1976.
4. J K Sharma, (1989), Mathematical Models in Operations Research: Tata McGraw Hill Publishing Company Ltd.
5. Srinath. L.S. PERT and CPM, Principles and Applications:2nd Edition, East-west press Pvt. Ltd.
6. Kantiswaroop and Manmohan Gupta. Operations Research: 4th Edition; S Chand & Sons
7. H. A.Taha., Operations Research: Prentice Hall of India.
8. J. K. Sharma. Quantitative Techniques For Managerial Decisions:(2001), MacMillan
9. Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), Operations Research: Methods and Problems: (1959), John Wiley & Sons.
10. Richard Bronson. Schaum Series book in O.R. 2nd edition, Tata Mcgraw Hill Publishing Company Ltd.

Program: Bachelor of Science			**Semester: III**
Course: Practical (Based on Modules USMAST301 USMAST302 AND USMAST303)			**Course Code: USMAST3123**
Teaching Scheme		**Evaluation Scheme**	
Practical (Lectures per week)	**Credit**	**Continuous Assessment (CA) (Marks - 30)**	**End Semester Examinations (ESE) (Marks- 40*3 = 120 in Question Paper)**
6	3	20%	80%

Outline of Syllabus: (per session plan)

No.	**Description**
Based on Module USMAST301	
1	Moment Generating functions
2	Cumulant Generating functions
3	Discrete Distributions
4	Fitting of Distributions
5	Bivariate Probability Distributions
6	Univariate Transformations
7	Bivariate Transformations
8	Inequalities
9	Modes of convergence and Law of Large numbers
Based on Module USMAST302	
1	Simple Random Sampling (WR/WOR).
2	Simple Random Sampling (Use of Random number Tables)
3	Simple Random Sampling (For Attributes)
4	Simple Random Sampling (Sample Size Determination and Confidence Intervals)
5	Stratified Random Sampling 1
6	Stratified Random Sampling 2
7	Ratio Method.
8	Regression Method.
Based on Module USMAST303	
1	Control Charts for Variables
2	Control Charts for Attributes
3	Single Sampling Plan
4	Double Sampling Plan
5	Gnatt Charts & Networks
6	CPM
7	PERT
8	Project Cost Analysis
9	Updating

Program: B.Sc.- Statistics		Semester : IV	
Course: : Distribution Theory II		Course Code: USMAST401	
Teaching Scheme		Evaluation Scheme	
Lecture (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
2	2	25%	75%

Learning Objectives:

Unit 1:

To make the learner aware of

1. Continuous probability distributions
2. Uniform distribution
3. Normal distribution, Standard normal distribution, Lognormal distribution.
4. Exponential distribution. Gamma and Beta distributions
5. Fitting of distributions.

Unit 2:

To make the learner aware of

1. The use a chi square test to evaluate the fit of a hypothesized distribution.
2. How the difference between the shape of the t distribution and normal distributionis affected by the degrees of freedom.
3. Use of the t table to find the value of t to use in a confidence interval
4. Use the t calculator to find the value of t to use in a confidence interval

Unit 3:

To make the learner aware of definition of F-distribution Summarize the F-statistic, the F-test and the F-distribution.

Course Outcomes:

After completion of the course, learners would be able to:

(CO1:Remember)

i) Definition of the Chi Square distribution in terms of squared normal deviates

(CO2:Understand)

i) Understand sampling distributions and application of chisquare and t distribution.

ii) Understand sampling distributions and applications of the Fdistribution.

iii) Identify the conditions which must be satisfied when using the chi-square test.

(CO3:Apply)

i) Apply Central limit theorem.

(CO4:Analyse)

i) Use of fitting of distribution.

ii) The difference between the shape of the t distribution and the normal distribution.

iii) Describe how the shape of the Chi Square distribution changes as its degrees offreedom increase.

(CO5:Evaluate)

i) Compute probability values for a continuous uniform probability distribution.

ii) Compute the expected value and variance for such a distribution.
iii) Compute probabilities using a normal probabilitydistribution.
iv) Compute probabilities using an exponential probabilitydistribution.

Outline of Syllabus: (per session plan)

Module	Description	No of Hours
1	Standard Continuous Distributions	10
2	Exact Sampling Distributions : Chi Square & Students t	10
3	Exact Sampling Distributions: F, Interdependence of Normal, Chi-square, t, F distributions	10
	Total	**30**

Module	Distribution Theory II	No. of Hours/ Credits 30/2
1	Standard Continuous Distributions	**10**
	❖ Rectangular, Triangular, And Normal, Lognormal, Gamma (1 & 2 parameters),Beta (Type I and Type II). ❖ The following aspects of the above distributions (wherever applicable) to bediscussed: ❖ Mean, Median, Mode Mean absolute deviation & Standard deviation. MomentGenerating Function, Additive property, Cumulant Generating Function. Moments(up to order 4), Recurrence relation for central moments, Skewness and Kurtosis. Fitting of Distributions. Interrelation between the distributions. ❖ Distribution of linear function of independent Normal variables. Fitting of Normal Distribution.	8 2
2	Exact Sampling Distributions : Chi Square & Students t	**10**
	Chi-Square Distribution: ❖ Moment generating function, Cumulant generating function. Additive property,Distribution of the sum of squares of independent Standard Normal variables. Sampling distributions of sample mean and sample variance and their independence for a sample drawn from Normal distribution (without proof). ❖ Confidence interval for the variance of a Normal population. t-distribution: ❖ Mean, Median, Mode & Standard deviation. ❖ Distribution of ratio of a Standard Normal variable to the square root of an independent Chi-square divided by its degrees of freedom. Asymptotic properties. Student's t. ❖ Confidence interval for: Mean of Normal population; Difference between means of two independent Normal populations havingthe	5 5

	same variance.	
3	Exact Sampling Distributions: F, Interdependence of Normal, Chi-square, t, F distributions.	**10**
	❖ Mean, Mode & Standard deviation. Distribution of : Reciprocal of an F variate, Ratio of two independent Chi-squares divided by their respective degrees of freedom. ❖ Confidence interval for ratio of variances of two independent Normal populations. Interrelationship of F with: t-distribution, Chi-square distribution & Normal distribution. ❖ Fisher's Z- transformation and its application.	5 5

Essential Readings:

1. S.C. Gupta, V.K. Kapoor; Fundamentals of MathematicalStatistics: 8th Edition;Sultan Chand & Sons.
2. A. M. Mood, F.A. Graybill, D. C. Boyes, Introduction to the theory of statistics: 3rd Edition; McGrawHill Book Company
3. R.V.Hogg, A.T. Craig; Introduction to Mathematical Statistics: Collier McMillanPublishers

Suggested Readings:

1. R.V.Hogg, E. A.Tannis, Probability and Statistical Inference: Collier McMillanPublishers.
2. John E. Freund's I. Miller, M. Miller, Mathematical Statistics: 6th Edition; Pearson Education Inc.
3. P.G. Hoel, Introduction to Mathematical Statistics, 4th Edition, John Wiley &Sons Inc.
4. J. Medhi, Statistical Methods: An Introductory Text, 2nd Edition,Wiley Eastern Ltd.
5. A.M. Goon, M.K. Gupta, B.DasGupta, An Outline of Statistical Theory Vol. 1: 3rd Edition, The World Press Pvt. Ltd.
6. Goon A.M., Gupta M.K.and Das Gupta B. (1986), Fundamentals of Statistics, Vol.II, World Press,Calcutta.

Program: B.Sc.- Statistics		**Semester : IV**	
Course: Analysis Of Variance & Design Of Experiments		**Course Code: USMAST402**	
Teaching Scheme		**Evaluation Scheme**	
Lecture (Hours per week)	**Credit**	**Continuous Assessment and Evaluation (CAE) (Marks - 25)**	**End Semester Examination (ESE) (Marks-75 in Question Paper)**
2	2	25%	75%

Learning Objectives:

To make the learner aware of

1. Understand what between-group and within-group variability consist of and represent.
2. Understand the role of between-group and within-group variability in testingdifferences between group means.
3. Understand what 'ANOVA' stands for, and why.
4. Understand why, in testing the difference between means, the inferential statisticis called the *F*-ratio.
5. Understand the characteristics of the theoretical distribution of *F*-ratios.
6.

Course Outcomes:

After completion of the course, learners would be able to:

(CO1:Remember)

i) Remember assumptions of ANOVA, mathematical models.

(CO2:Understand)

i) Understand concept of Analysis of Variance (ANOVA)

(CO3:Apply)

i) Apply ANOVA and design of experiments in different situation.

(CO4:Analyse)

i) Discuss a Statistical Test for One-Way ANOVA and Two –Way ANOVA

(CO5:Evaluate)

i) compute last square estimates of unknown parameters and their variances.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of hours**
1	ANOVA	10
2	Design Of Experiments, Completely Randomized design & Randomized Block Design.	10
3	Latin Square Design, Factorial Experiments.	10
	Total	30

Module	Analysis Of Variance & Design Of Experiments	No. of Hours/ Credits 30/2
1	ANOVA	**10**
	❖ Introduction, Uses, Cochran's Theorem (Statement only). ❖ One-way classification with equal & unequal observations per class. Two-way classification with one observation per cell. ❖ Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table. ❖ Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard Error and Confidence limits forelementary treatment contrasts.	
2	Design Of Experiments, Completely Randomized design & Randomized Block Design.	**10**
	Design of Experiments: ❖ Concepts of Experiments, Experimental unit, Treatment, Yield, Block, Replicate, Experimental Error, Precision. Principles of Design of Experiments: Replication, Randomization & Local Control. ❖ Efficiency of design D1 with respect to design D2. ❖ Choice of size, shape of plots & blocks in agricultural & nonagricultural experiments. Completely Randomized Design (CRD), Randomized Block Design (RBD): Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table. Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard error and Confidence limits forelementary treatment contrasts. Efficiency of RBD relative to a CRD. Missing plot technique for one missing observation in case of CRD, RBD.	4 6
3	Latin Square Design, Factorial Experiments	**10**
	Latin Square Design (LSD): ❖ Mathematical Model, Assumptions, Expectation of various sums of squares,F-test, Analysis of variance table. Least square estimators of the parameters, ❖ Variance of the estimators, Estimation of treatment contrasts, Standard error andConfidence limits for elementary treatment contrasts. Efficiency of the design relative to RBD, CRD. ❖ Missing plot technique for one missing observation in case of LSD. Factorial Experiments. Definition, Purpose & Advantages. 2^2, 2^3 Experiments. Calculation of Main &interaction Effects. Yates' method. Analysis of 2^2 & 2^3 factorial Experiments.	5 5

Essential Readings:

1. S.C.Gupta and V.K.Kapoor, Fundamentals of Applied Statistics, 4th Edition, Sultan Chand and Sons(2001).
2. Douglas C Montgomery, Design and Analysis of Experiments, 6th Edition, John Wiley & Sons.

Suggested Readings:

1 Das, M.N. and Giri J. (1986), Design and Analysis of Experiments, Springer Verlag.
2 Kempthorne O. (1965), The Design and Analysis of Experiments, Wiley Eastern.
3. Cochran W.G. and Cox Experimental Design, John Wiley and G.M. (1957) Sons.
4. Walter T Federer, Experimental Design, Theory and Application: Oxford & IBH Publishing Co. Pvt. Ltd.
5. B.J. Winer, Principles in Experimental Design: McGraw HillBook Company.

Program: B.Sc.	**Semester: IV**
Course: APPLIED STATISTICS 2: (Vital Statistics, Simulation, Reliability)	**Course Code: USMAST403**

Teaching Scheme		**Evaluation Scheme**	
Lecture (Hours per week)	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
2	2	25%	75%

Learning Objectives:

1. The learner will learn various measures of Mortality, Fertility.
2. The learner will learn the concept of reliability, hazard function and its derivation for standard distributions. Also derivation of reliability of series and parallel systems.
3. To make the learner aware of necessity of simulation in real life and its applications. Also learn Monte Carlo Technique of Simulation.

Course Outcomes:

After completion of the course,

CO1: Learner will able to perform calculations of various measures of Mortality, Fertility.

CO2: The learner will able to compute reliability, hazard function for standard distributions. Also reliability of series and parallel systems.

CO3: The learner will be able to generate random sample from various standard distributions. Also, will able to use Monte Carlo Technique of Simulation in real examples.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Vital Statistics	10
2	Simulation	10
3	Reliability	10
	Total	**30**

Module	**Vital Statistics, Simulation, Reliability**	**No. of Hours/Credits 30/2**
1	**Vital Statistics**	**10**
	❖ Introduction and use of Vital Statistics	2
	❖ Methods of obtaining Vital Statistics	
	❖ Measurement of population, Rates and ratios of vital events.	2
	❖ Measures of Mortality: Crude Death Rate (CDR), Specific Death Rates (SDR), Age Specific Death Rate (Age-SDR), Infant Mortality Rate	

	(IMR) and Standardized Death Rates (Direct and Indirect methods of standardisation). ❖ Measures of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR), Age-Specific Fertility Rate (Age-SFR) & Total Fertility Rate (TFR). ❖ Measurement of Population Growth : Crude Rate of Natural Increase and Pearle's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR). ❖ Concept of Stable and Stationary populations. ❖ Concept and determination of rate of increase in stable population. ❖ Logistic curve for Population growth: Method of Pearl and Reed, Method due to Rhodes.	2 2 2
2	**SIMULATION**	**10**
	❖ Concept of simulation ❖ Types of simulation ❖ Random Numbers : Their properties and generation by using Mid-Square method and Multiplicative Congruential method. ❖ Sampling from probability distributions: ▪ Inverse transform method : i. Uniform distribution ii. Exponential distribution ▪ Convolution method : i. Gamma distribution ii. Normal distribution ▪ Box-Muller method : i. Normal distribution ❖ Monte Carlo Technique of Simulation. ❖ Simulation techniques applied to inventory and Queuing models.	2 2 3 **3**
3	**RELIABILITY**	**10**
	❖ Concept of Reliability, Hazard-rate. ❖ Expression of hazard function in terms of density function and reliability function. ❖ Expression of density function and reliability function in terms of hazard function. ❖ Definitions of increasing and decreasing failure rate, Mean Time to Failure (MTTF). ❖ Bath tub curve ❖ Reliability function, hazard function and nature of hazard function for following Failure time distributions: ▪ Exponential distribution ▪ Gamma distribution ▪ Weibull distribution ▪ Gumbel distribution ❖ Two parameter exponential distribution ❖ Reliability of system, Reliability of series and parallel system of independent components. ❖ Reliability of series and parallel system of independent components having exponential life distributions.	3 3 3 2

Essential Readings:

1. Gupta S. C. &. Kapoor V. K. Fundamentals of Applied Statistics, 4th edition, Sultan Chand & Sons.
2. Sharma J. K. Operations Research Theory and Application, 3rd edition Macmillan India Ltd.
3. Barlow R.E. and Prochan Frank Statistical Theory of Reliability and Life Testing Reprint, 1st edition, Holt, Reinhart and Winston.

Reference Books

1. Spiegel M.R. Theory and Problems of Statistics, 4th edition, Schaum's Outline Series Tata McGraw Hill
2. Taha Hamdy A. Operations Research : 8th edition Prentice Hall of India Pvt. Ltd
3. Vora N. D. Quantitative Techniques in Management, 3rd edition, McGraw Hill Companies.

Program: Bachelor of Science			**Semester: IV**
Course: Practical (Based on Modules USMAST401 USMAST402 AND USMAST403)			**Course Code: USMAST4123**
Teaching Scheme		**Evaluation Scheme**	
Practical (Lectures per week)	**Credit**	**Continuous Assessment (CA) (Marks - 30)**	**End Semester Examinations (ESE) (Marks- 40*3 = 120 in Question Paper)**
6	3	20%	80%

Outline of Syllabus: (per session plan)

No.	**Description**
Based on Module USMAST401	
1	Uniform and Triangular Distribution
2	Exponential Distribution
3	Gamma and beta Distributions
4	Normal Distribution
5	Fitting of Continuous Distributions
6	Chi-square distribution
7	t – Distribution
8	F- distribution
9	Fishers Z transformation
Based on Module USMAST402	
1	One Way ANOVA.
2	Two Way ANOVA.
3	Completely Randomized Design.
4	Randomized Block Design.
5	Latin Square Design.
6	Missing Plot Technique.
7	Factorial Experiments 1
8	Factorial Experiments 2
Based on Module USMAST403	
1	Vital Statistics 1
2	Vital Statistics 2
3	Simulation 1
4	Simulation 2
5	Reliability 1
6	Reliability 2