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: 3.37,
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: Bachelor of Science (Honours)

Applied Statistics & Data Analytics

S. Y. B. Sc.

Semester III & IV

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

A.C. No: 13
Agenda No: 3 (VIII)

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.

In the subject of Mathematics, the learner was taught the Discrete Mathematics and Real Analysis which are required to gain advanced knowledge and applications of the subject.

He was also introduced to Computer Fundamentals, C- programming, Use of R software and Excel for Statistical computations. He is now ready to take up learn the advanced studies in Statistics, Mathematics and Programming.

In the second year of under-graduation, the learner will be 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 the industry will be studied. Learners will be encouraged to complete the practical assignments using R software. Latex is introduced in the third semester so that it may help him in report preparing and documentation.

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

The courses are as follows: -

Semester III:	USMAAS301:	Probability Distributions III.
	USMAAS302:	Sampling Techniques.
	USMAAS303:	Industrial Statistics.
	USMAAS304:	Discrete Mathematics 3.
	USMAAS305:	Linear Algebra 1.
	USMAAS306:	Python Fundamentals.
	USMAAS307:	Applied Component 3 (Latex).
	USMAASP3123:	Statistics Practical 3 (Based on Courses USMAAS301, USMAAS302 and USMAAS303).
	USMAASP345:	Mathematics Practical 3 (Based on Courses USMAAS3 04 and USMAAS305).
	USMAASP36:	Python Practical (Based on Course USMAAS306).
Semester IV:	USMAAS401:	Probability Distributions IV.
	USMAAS402:	Design of Experiments.
	USMAAS403 :	Operations Research I.
	USMAAS404:	Numerical Analysis.
	USMAAS405:	Linear Algebra 2.
	USMAAS406:	Advanced R.
	USMAAS407:	Applied Component 4 (Basic Data Mining Concepts).
	USMAASP4123:	Statistics Practical 4 (Based on Courses USMAAS401, USMAAS402 and USMAAS403).

USMAASP445:	Mathematics Practical 4 (Based on Courses USMAAS404 and USMAAS405).
USMAASP46:	Advanced R Practical (Based on Course USMAAS406).

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

N.B.- (i) The duration of each theory lecture will be of 60 minutes. A course consists of 3 units. For each unit the number of hours allotted are 15. The total number of lecture hours for each course will thus be 45.

For the theory component the value of One Credit is equal to 15 learning hours.

(ii) There will be one practical per batch for each course. The duration of each practical will be of 2 hours, i.e. of 120 minutes.

For practical component the value of One Credit is equal to 30 learning hours.

(iii) Thus in a week, a student will study 3 hours of theory and 2 hours of practical for each course.

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.- Applied Statistics & Data Analytics (Honours)			Semester : III
Course: Probability Distributions III			Course Code: USMAAS301
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

Unit 1:

- To learn the definition of a moment-generating function.
- To find the moment-generating functions of Standard Discrete random variables.
- To learn how to use a moment-generating function to find the mean and variance of a random variable.
- To learn how to use a moment-generating function to identify which probability mass function a random variable X follows.
- To introduce the learner to the concept of Probability Generating Functions.

Unit 2:

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

Unit 3:

- Making use of joint probability mass function and joint probability density to calculate probabilities.
- 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.

Course Outcomes:

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

(CO1: Remember)

i. Recall definitions of probability function, density function, cumulative distribution function 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 of maximum 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 a range of probability distributions

(CO4: Analyse)

i. Distinguish between the different discrete and continuous distributions.
ii. The basics of asymptotic analysis in statistics and probability
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 marginal and conditional probabilities and the covariance of two random variables.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Generating Functions.	15
2	Limit Theorems , WLLN SLLN,CLT's	15
3	Bivariate Distributions and Transformation of Variables	15
	Total	45
Module	Probability Distributions III	No. of Hours/Credits 45/3
1	Generating Functions.	15
	❖ Moment Generating Function, Cumulant generating function- their important properties. Examples; Relationship between moments and cumulants and their uses.	6
	❖ Characteristic Function- Its properties (without proof).	2
	❖ Probability Generating Functions; Properties and Results with proofs and Applications.	7
2	Limit Theorems , WLLN SLLN,CLT's	15
	❖ Limit laws: Convergence in probability, almost sure convergence.	4
	❖ Chebyshev's inequality - Convergence in probability and in distribution	3
	❖ Convergence in distributions– Limit Laws Weak / Strong Law of Large Numbers	3
	❖ Central limit theorem and its applications	2
	❖ Liapunov Theorem.	1
	❖ DeMoivre - Laplace Limit Theorem.	2
	❖ Lindeberg- Levy theorem	
3	Bivariate Distributions & Transformation of Variables	15
	❖ Joint Probability mass function for Discrete random variables.	4
	❖ Joint Probability density function for continuous random variables.	
	❖ Their properties.	

	❖ Marginal and Conditional Distributions. ❖ Independence of Random Variables. ❖ Conditional Expectation & Variance. ❖ Regression Function. Coefficient of Correlation. ❖ 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. ❖ Transformation of Random Variables and Jacobian of transformation with illustrations.	4 3 4

ESSENTIAL READINGS:

1. Prem S. Mann, Introductory Statistics, Wiley Plus., 9th edition, July 2018.
2. Hogg R.V. and Tannis E.P., Probability and Statistical Inference, McMillan Publishing Co.
3. Jay L. Devore, Probability and Statistics for Engineers and the Sciences, Cengage Learning, 9th edition.

SUPPLEMENTARY READINGS:

1. S. M. Ross Sheldon, Introductory Statistics. Academic Press, 4th edition.
2. Statistics - An Introduction, Roger Kirk, 5th edition, Thompson Wadsworth.
3. David R. Anderson, Dennis J. Sweeney, Thomas A. Williams - Statistics for Business & Economics-Cengage (2019).
4. Ken Black, Business Statistics for Contemporary Decision making, Wiley Plus, 9th edition.
5. Roxy Peck, Jay L. Devore, Statistics: The Exploration & Analysis of Data, Cengage Learning, 7th edition.
6. Statistics for Management, Masood Husain Siddiqui, Richard I. Levin, David S. Rubin, Sanjay Rastogi, Pearson ,8th edition.
7. Jay L. Devore, Kenneth N. Berk (auth.) - Modern Mathematical Statistics with Applications, Springer-Verlag, New York 2nd edition, (2012).
8. S.C. Gupta, V.K. Kapoor; Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 8th Edition.

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : III
Course: Sampling Techniques			Course Code: USMAAS302
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

Unit 1:

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

Unit 2:

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

Unit 3:

- To make the learner aware of Ratio & Regression Methods of Estimation and Systematic Sampling.
- To make the learner aware of the Statistical agencies functioning in India.
- 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.	15
2	Stratified Sampling.	15
3	Ratio and Regression methods. Concepts of Systematic Sampling. Indian Statistical agencies and their functions.	15
	Total	45
Module	Sampling Techniques	No. of Hours/Credits 45/3
1	Sampling Concepts and Simple random Sampling for Variables and Attributes	15
	❖ 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 with examples 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	Stratified Random Sampling	15
	❖ 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 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. ❖ Concept and basic ideas of Cluster sampling, Two-stage sampling and Multi Stage sampling.	
3	Ratio And Regression methods. Concepts of Systematic Sampling. Indian Statistical agencies and their functions	15
	❖ Ratio & Regression Methods of Estimation. ❖ Ratio Estimators for population Ratio, Mean & Total. Expectation & MSE of the Estimators. Estimators of MSE, Uses of Ratio Estimator. ❖ 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. Comparison of Ratio, Regression & mean per Unit estimators. ❖ Systematic Sampling. ❖ Statistical Organization's, NSSO, CSO and their functions.	

ESSENTIAL READINGS:

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

SUPPLEMENTARY READINGS:

1. Des Raj (2000): Sample Survey Theory Narosa Publishing House, New Delhi.
2. Daroga Singh, F.S.Chaudhary: Theory and Analysis of Sample Survey Designs: Wiley Eastern Ltd. (1986)
3. Sukhtme P.V., Sukhatme B.V., Sukhatme S. and Asok C. (1984): Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi
4. P.V. Sukhatme and B.V. Sukhatme. Sampling Theory of Surveys with Applications:3rd Edition; Iowa State University Press (1984)
5. Murthy M.N. (1967): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
6. Sampath S. (2000) : Sampling Theory and Methods, Narosa Publishing House, New Delhi.
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.- Applied Statistics & Data Analytics (Honours)			Semester : III
Course: Industrial Statistics			Course Code: USMAAS303
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

Unit 1:

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

Unit 2:

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

Unit 3:

- Understand the role and application of PERT/CPM for project scheduling.
- Learn how to define a project in terms of activities such that a network can be used to describe the project.
- Know how to compute the critical path and the project completion time.
- Know how to convert optimistic, most probable, and pessimistic time estimates into expected activity time estimates.
- With uncertain activity times, be able to compute the probability of the project being completed by a specific time.
- Understand the concept and need for crashing.
- 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 to meet 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	15
2	Acceptance Sampling plans	15
3	PERT-CPM	15
	Total	45
Module	Probability Distributions III	No. of Hours/Credits 45/3
1	Control Charts and	15
	❖ Principles of control. Process quality control of attributes and variables. ❖ ($\bar{X}$, R), Chart; ❖ p, c, np charts; ❖ p-chart with variable sample size, ❖ Uses and applications. ❖ Problems involving setting up standards for future use.	3 5 5 2
2	Acceptance Sampling	15
	❖ 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. ❖ Multiple sampling plans. ❖ Introduction to Six sigma limits.	2 5 5 3
3	PERT – CPM 1	15
	❖ Objective and Outline of the techniques. Diagrammatic representation of activities in a project: Gantt Chart and Milestone Charts, ❖ PERT Network: Events and Activities, Networks, Numbering of Events; Time Estimates; Single v/s Multiple Time estimates. ❖ Reduction of Data: Mean, Variance and Standard Deviation, probability distributions; Normal; Beta, Expected Time Diagram Slack time and Float times. Determination of Critical ❖ Computations of Earliest expected time, Latest Allowable	2 3 3

	Occurrence time, Forward and Backward Pass., Slack, Critical Path, Probability of achieving completion date; Application of CLT, Application to a Network. ❖ Critical Path Method: Drawing and numbering the network; Time Estimates, Earliest expected time, Latest Allowable Occurrence time, Forward and Backward Pass, Slack Time and Critical Path, Floats. ❖ Project cost analysis: Cost v/s Time; Straight Line and segmented Approximations, Optimum Duration, Contracting the Network, Graph Reduction Theorem. ❖ Uses and Applications of PERT CPM Techniques.	3 4

ESSENTIAL READINGS:

1. Douglas C Montgomery; Introduction to Statistical Quality Control. 6th Edition, (2009) John Wiley and sons Inc.
2. L. S. Srinath, PERT and CPM Principles and Applications, 3rd Edition, Affiliated East-West Press (Pvt.) Ltd.

SUPPLEMENTARY READINGS:

1. Duncan., Quality Control and Industrial Statistics: D. Taraporewal Sons & Company. 2nd edition
2. E.L. Grant. Statistical Quality Control: 2nd edition, McGraw Hill, 1988.
3. Bertrand L. Hansen, (1973) Quality Control: Theory and Applications: (1973), Prentice Hall of India Pvt. Ltd.
4. I.V. Burr, Mardekkar, Quality Control: New York, 1976.J K Sharma, (1989), Mathematical Models in Operations Research: Tata McGraw Hill Publishing Company Ltd.
5. S.D. Sharma.11th edition, Operations Research:.11th edition, KedarNath Ram Nath & Company.
6. Kantiswaroop and Manmohan Gupta. Operations Research: 4th Edition; S Chand & Sons
7. H. A. Taha., Operations Research: Prentice Hall of India. 10th Edition.
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., Tata McGraw Hill Publishing Company Ltd. 2nd edition .

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : III
Course: Discrete Mathematics 3			Course Code: USMAAS304
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

- To make the learner aware that Discrete mathematics has applications to almost all conceivable area of study.
- To introduce the learner to the concept of Groups, Permutation functions, Rings and fields.
- To make the learner aware that modelling with discrete mathematics is an extremely important problem solving skill and they have an opportunity to develop by constructing their own models

Course Outcomes:

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

CO1: Discuss examples of groups, properties of groups; operations on groups. The nature of orbits, cycles, the alternating group, cyclic groups, abelian groups, cosets and Lagrange's theorem.
The concepts of an extension field, and of algebraic elements and of transcendental elements and how these tie together to show that every non-constant polynomial has a zero in some field.
Recall various logic gates and the rules of Boolean algebra.
Grammers are used to generate the words of language.

CO2: Discuss sets, subsets, and partitions and equivalence relations.
Discuss different simplification methods for Boolean functions
Formal languages provide models for programming languages like pascal, fortran, C and so on.

CO3: Discuss examples of groups, properties of groups; operations on groups. The nature of orbits, cycles, the alternating group, cyclic groups, abelian groups, cosets and Lagrange's theorem
Realize the combinational and sequential logic circuits by using various logical blocks.
Analyzing
To determine if a word is in a language.

CO4: Explain Homomorphisms, or relationships between groups such as isomorphism and factor groups and Cayley's theorem.
Design synchronous counters and develop sequential circuit applications using flip flop and registers.
Use to Turing machines to recognize sets.

CO5: Compare rings, integral domains, and fields; structures with two binary operations defined on them. Discuss Fermat's and Euler's theorems.
Demonstrate knowledge of why the real and complex numbers are each a field, and that particular rings are not fields (e.g., integers, polynomial rings, matrix rings)
Every effective computation can be carried out by a Turing Machine.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Algebraic Structures	15
2	Boolean Algebra.	15
3	Modelling Computation	15
	Total	45
Module	Discrete Mathematics 3	No. of Hours/Credits 45/3
1	Algebraic Structures	15
	Introduction, Algebraic Systems, Semigroups and Monoids Groups, Subgroups, Cyclic Groups, Homomorphism's. Cosets and Normal Subgroups. Permutation Functions. Rings and Fields.	4 4 4 3
2	Boolean Algebra	15
	Introduction, Boolean Expressions and Boolean Functions, Identities, Duality, Abstract Definition of a Boolean Algebra, Representation of Boolean functions, Functional Completeness, Logic Gates, Combination of Gates, Circuits, Adders, Minimization of Circuits. Karnaugh Maps, Don't Care Conditions, The Quine-McCluskey Method.	5 5 5
3	Modelling Computation	15
	Languages and Grammars: Introduction, Phrase Structure Grammars with Types, Derivation Tress, Backus-Naur Form, Finite-State Machines with Output: Introduction, Finite State Machines with Outputs. Finite-State Machines with No Output: Introduction, Set of Strings, Finite-State Automata, Language Recognition by Finite-State Machines, Nondetermistics Finite-State Automata, Language Recognition: Introduction, Kleene's Theorem, regular Sets and Regular Grammars, A set not Recognised by a Finite-State Automation, More Powerful Types of Machines, Turing Machines: Introduction, Definition, using Turing Machine to Recognize Sets, Computing Functions with Turing Machines, Different Types of Types of Turing Machines, The Church-Turing Thesis, Computational Complexity, computability and decidability.	3 3 3 3 3

ESSENTIAL READINGS:

1. B. V. Senthil Kumar and Hemen Dutta, (2020), Discrete Mathematical Structures, CRC Press.
2. Kenneth H. Rosen, Discrete Mathematics and Its Applications Eighth Edition, McGraw Hill Education.

SUPPLEMENTARY READINGS:

1. Edgar Goodaire, Michael Parmenter, (2002) Discrete Mathematics with Graph Theory, 8th Edition, Prentice Hall.
2. B. Kolman R. Busby S. Ross, (2014), Discrete Mathematical Structures, Sixth Edition, Pearson New International Edition.

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : III
Course: : Linear Algebra 1			Course Code: USMAAS305
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

- To understand the basic concepts of linear algebra
- Use proper notations for linear algebra.
- To introduce the learner to matrix algebra.
- To achieve computational proficiency involving procedures in linear algebra.
- To Solve a system of linear equations
- To understand the axiomatic structure of a modern mathematical subject and learn to construct simple proofs.
- To introduce the learner to Analyze vectors in Rn geometrically and algebraically.
- To Learn the applications of linear algebra.
- To introduce the learner to the Matlab software.

Course Outcomes:

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

CO1: (Remember)
Recognize the concepts of the terms span, linear independence, basis, and dimension, and apply these concepts to various vector spaces and subspaces.

CO2: (Understand)
The concepts of vector space and subspace. (understand)
Linear independence, span, and basis.

CO3: (Apply)
Principles of matrix algebra to linear transformations.
Matrix operations, including inverses and determinants.

CO4: (Analyse)
Demonstrate understanding of inner products and associated norms.)
Determine if a set of vectors is a vector space, a subspace, or a basis for a vector space.

CO5: (Evaluate)
Solve systems of linear equations using multiple methods, including Gaussian elimination and matrix inversion.
Carry out matrix operations, including inverses and determinants.
Compute and use determinants Determine eigenvalues and eigenvectors and solve eigenvalue problems.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Linear Equations and Matrices	15
2	Determinants , Vectors in R^n,	15
3	Real Vector Spaces.	15

	Total	45
Module	Linear Algebra 1	No. of Hours/Credits 45/3
1	Linear Equations and Matrices	15
	Linear Systems, Matrices, Dot product and Matrix Multiplication. Properties of Matrix Operations, Solutions of Linear System of Equations, Inverse of a Matrix. LU- Factorization Applications: Markov Chains ; Linear Economic Models	5 5 4
2	Determinants , Vectors in Rn	15
	Definition and Properties., Cofactor Expansion and Applications Determinants from a Computational point of View. Vectors in a plane,n-Vectors, Introduction to Linear transformations. Application in R2 and R3: Computer Graphics, Cross Product in R3, limes and Planes.	6 4 5
3	Real Vector Spaces.	15
	Vector Spaces, Subspaces, Linear Independence. Basis and Dimensions, Homogeneous Systems. Rank of a matrix, Applications. Coordinates and Change of Basis, Orthonormal Bases in Rn, Orthogonal Complements. Applications: QR-factorization; Least Squares	4 2 2 5 2

ESSENTIAL READINGS:

1. Bernard Kolman David Hill, (2014), Elementary Linear Algebra with Applications, 9th Edition, Pearson.
2. Gareth Williams, (2019), Linear Algebra with Applications, 9th Edition, Jones and Bartlett Learning.

SUPPLEMENTARY READINGS:

1. Gilbert Strang, Introduction to Linear Algebra 5th Edition, Wellesley - Cambridge Press
2. Serge Lang, Introduction to Linear Algebra-Springer-Verlag New York (1986)
3. David Poole - Linear Algebra - A Modern Introduction-Cengage Learning (2015).
4. K. Hoffman and R. Kunze, “Linear Algebra”, Prentice Hall, (2008).
5. Gilbert Strang, (2019) Linear Algebra and Learning from Data, Wellesley- Cambridge Press.
6. Kenneth Kuttler, (2020), Linear Algebra, Theory and Applications. World Scientific.

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : III
Course: Python Fundamentals			Course Code: USMAAS306
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

- To introduce various concepts of programming to the students using Python.
- To learn the syntax of writing various commands of Python
- To develop logic for Problem Solving with the help of Python
- To learn about the basic constructs of programming such as data, operations, conditions, loops, functions etc.

Course Outcomes:

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

CO1: (Remember)
The concepts of programming before actually starting to write programs.
the concepts of, widgets, GUI applications and database connectivity.

CO2: (Understand)
The concepts of programming before actually starting to write programs.

CO3: (Apply)
Basic constructs of programming such as data, operations, conditions, loops, functions etc.

CO4: (Analyse)
What is pattern making?
Find his own mistakes during program execution.
Develop logic reasoning skills.

CO5: (Evaluate)
Problem solving skills using syntactically simple language.
To read and write files.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Introduction , Python Basics	15
2	Functions , Lists, Tuples Dictionaries, Files	15
3	Expressions, Classes and Objects Modules, Widgets, Gui Applications	15
	Total	45
Module	Python Fundamentals	No. of Hours/Credits 45/3
1	Introduction , Python Basics	15
	Introduction: The Python Programming Language, History, features, Installing Python, Running Python program, Debugging: Syntax Errors, Runtime Errors, Semantic Errors, Experimental Debugging,	3

	Formal and Natural Languages, The Difference Between Brackets, Braces, and Parentheses, Variables and Expressions Values and Types, Variables, Variable Names and Keywords, Type conversion, Operators and Operands, Expressions, Interactive Mode and Script Mode, Order of Operations. Conditional Statements: if, if-else, nested if –else. Looping: for, while, nested loops Control statements: Terminating loops, skipping specific conditions. Strings: A String Is a Sequence, Traversal with a for Loop, String Slices, Strings Are Immutable, Searching, Looping and Counting, String Methods, The in Operator, String Comparison, String Operations.	 3 5 4
2	Functions , Lists, Tuples, Dictionaries, Files	15
	Functions: Function Calls, Type Conversion Functions, Math Functions, Composition, Adding New Functions, Definitions and Uses, Flow of Execution, Parameters and Arguments, Variables and Parameters Are Local, Stack Diagrams, Fruitful Functions and Void Functions, Why Functions? Importing with from, Return Values, Incremental Development, Composition, Boolean Functions, More Recursion, Leap of Faith, Checking Types Lists: Values and Accessing Elements, Lists are mutable, traversing a List, Deleting elements from List, Built-in List Operators, Concatenation, Repetition, In Operator, Built-in List functions and methods Tuples and Dictionaries: Tuples, accessing values in Tuples, Tuple Assignment, Tuples as return values, Variable-length argument tuples, Basic tuples operations, Concatenation, Repetition, in Operator, Iteration, Built-in Tuple Functions Creating a Dictionary, Accessing Values in a dictionary, Updating Dictionary, Deleting Elements from Dictionary, Properties of Dictionary keys, Operations in Dictionary, Built-In Dictionary Functions, Built-in Dictionary Methods. Files: Text Files, The File Object Attributes, Directories Exceptions: Built-in Exceptions, Handling Exceptions, Exception with Arguments, User-defined Exceptions.	5 4 3 3
3	Expressions, Classes and Objects Modules, Widgets, GUI Applications	15
	Regular Expressions – Concept of regular expression, various types of regular expressions, using match function. Classes and Objects: Overview of OOP (Object Oriented Programming), Class Definition, Creating Objects, Instances as	4

	Arguments, Instances as return values, Built-in Class Attributes, Inheritance, Method Overriding, Data Encapsulation, Data Hiding Modules: Importing module, Creating and exploring modules, Math module, Random module, Time module Widgets: Button, Canvas, Checkbutton, Entry, Frame, Label, Listbox, Menubutton, Menu, Message, Radiobutton, Scale, Scrollbar, text, Toplevel, Spinbox, PanedWindow, LabelFrame, tkMessagebox. Handling Standard attributes and Properties of Widgets. Layout Management: Designing GUI applications with proper Layout Management features. Look and Feel Customization: Enhancing Look and Feel of GUI using different appearances of widgets.	4 4 2

ESSENTIAL READINGS:

1. Paul Gries Jennifer Campbell Jason Montojo, Practical Programming, An Introduction to Computer Science Using Python 3.6, Third Edition. The Pragmatic Programmers, LLC.
2. Kenneth A. Lambert, B.L. Juneja, Fundamentals of Python, Cengage Learning India Pvt. Ltd. (2015).

SUPPLEMENTARY READINGS:

1. James Payne, Beginning Python, (2010), Wrox programmer to Programmer.
2. James Payne, Python for Teenagers: Learn to Program Like a Superhero! Apress (2019).
3. Charles Dierbach, Introduction to Computer Science Using Python: A Computational Problem-Solving Focus, Wiley. (2013).

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : III
Course: Applied Component 3 : Latex			Course Code: USMAAS307
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
02	02	25	75

Learning Objectives:

- To introduce the learner to LaTex, a high quality open source typesetting software

Course Outcomes:

After completion of the course, learners will:

CO1 : (Remember)

To use Latex for type setting documents.

CO2 : (Understand)

To fine-tune text, formulae page layout, proceed with managing complex documents and using modern PDF features.

CO3 : (Apply)

Learn to use macros and styles to maintain a consistent document structure while saving typing work.

CO4: (Analyse)

Know how to create professional-looking tables, along with including figures and writing complex mathematical formulas. Know how to generate bibliographies and indexes with ease.

CO5 : (Evaluate)

The learner will be able to typeset documents containing tables, figures, formulas, and common book elements such as bibliographies, glossaries, and indexes.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Getting Started, Formatting Text and Creating Macros, Designing Pages	10
2	Creating Lists, Including Images Creating Tables, Using Cross-References	10
3	Writing Math Formulae, Using Fonts, Developing Large Documents, Enhancing Documents Troubleshooting, Using Online Resources.	10
	Total	30
Module	Applied Component 3 (Latex)	No. of Hours/Credits 30/2
1	Getting Started, Formatting Text and Creating Macros, Designing Pages	10
	Getting Started with LaTeX, Installing and using LaTeX, working with LaTeX online using Overleaf, Accessing documentation	3 4

	Formatting Text and Creating Macros: Working with logical formatting, Understanding how LaTeX reads our input, printing out special symbols, Modifying the text fonts Creating our own commands, using boxes to limit the width of paragraphs, breaking lines and paragraphs, turning off full justification, Displaying quotes. Designing Pages: Creating a book with chapters, Defining the margins, using class options, designing headers and footers, using footnotes, breaking pages, enlarging a page, Changing the line spacing, Creating a table of contents.	3
2	Creating Lists, Including Images Creating Tables, Using Cross-References	15
	Creating Lists: Building lists, Customizing lists. Including Images: Including an image, Managing floating images. Creating Tables: Using tab stops to write in columns, Typesetting tables, adding captions to tables, Using packages for further customizations. Using Cross-References: Setting labels and references, using advanced referencing, referring to labels in other documents, Turning references into hyperlinks. Listing Contents and References: Customizing the , Generating an index, Creating a bibliography, Changing the headings.	2 1 3 2 2
3	Writing Math Formulae, Using Fonts, Developing Large Documents, Enhancing Documents Troubleshooting, Using Online Resources.	15
	Writing Math Formulas: Writing basic formulas, typesetting multi-line formulas, Exploring the wealth of math symbols, Building math structures. Using Fonts: Using comprehensive font bundles, using specific font families, Using arbitrary fonts. Developing Large Documents: Splitting the input, creating front and back matter, designing a title page, Working with templates. Enhancing Your Documents Further: Using hyperlinks and bookmarks, designing headings, Coloring our documents. Troubleshooting: Understanding and fixing errors, Handling warnings, Avoiding obsolete classes and packages. General troubleshooting. Using Online Resources: Web forums, Lists of frequently asked questions, Mailing lists, TeX user group sites. Websites for LaTeX software and editors, Graphics galleries, LaTeX blogs.	3 2 2 1 1 1

ESSENTIAL READINGS:

1. Stefan Kottwitz - LaTeX Beginner's Guide-Packt Publishing (2021).
2. Dilip Datta (auth.) - LaTeX in 24 Hours_ A Practical Guide for Scientific Writing-Springer International Publishing (2017).

SUPPLEMENTARY READINGS:

1 Leslie Lamport - The LaTeX companions. Bind 4 _ LaTeX _ a document preparation system, user's guide and reference manual (Bookmarked)-Addison-Wesley (2001)
2. Stefan Kottwitz - LaTeX Cookbook, Packt Publishing (2015).
3. Grätzer, George - Practical LaTeX-Springer (2014).

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : III
Course: Statistics Practical 3 (Based on Courses USMAAS301, USMAAS302 and USMAAS303).			Course Code: USMAASP3123
Teaching Scheme	Evaluation Scheme		
Practicals (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks – 20%) 10 Marks in Each Component	End Semester Examination (TEE) (Marks-80% in Question Paper) 40 Marks in Each Component)
06	03	30	120

Learning Objectives and Course Outcomes:
As per Courses USMAAS301, USMAAS302 AND USMAAS303

Module	Statistics Practical 3 (Based on Courses USMAAS301, USMAAS302 and USMAAS303).	No. of Hours/Credits 90/3
Sr. No.	**Based on Course USMAAS301.**	
1	Moment Generating Functions.	
2	Cumulant Generating Functions.	
3	Probability Generating Functions	
4	Chebyshev's Inequality.	
5	Law of Large Numbers 1	
6	Law of Large Numbers 2	
7	Joint probability Distributions 1	
8	Joint Probability Distributions 2	
9	Transformation of Variables 1	
10	Transformation of Variables 2	
Sr. No.	**Based on Course USMAAS302.**	
1	Results of SRSWR.	
2	Results of SRSWOR.	
3	Use of Random Number tables.	
4	Sampling for Variables	
5	Sampling for Attributes	
6	Stratified Sampling 1	
7	Stratified Sampling 2	
8	Ratio Method	
9	Regression Method	
10	Systematic Sampling	
Sr. No.	**Based on Course USMAAS303.**	
1	Control Charts 1	
2	Control Charts 2	
3	Control Charts 3	
4	Control Charts 4	

5	Acceptance Sampling Plans 1
6	Acceptance Sampling Plans 2
7	PERT – CPM 1
8	PERT – CPM 2
9	PERT – CPM 3
10	PERT – CPM 4

Program: B.Sc.- Applied Statistics And Data Analytics (Honours)			Semester : III
Course: Mathematics Practical 3 (Based on Courses USMAAS304 and USMAAS305.			Course Code: USMAASP345
Teaching Scheme		Evaluation Scheme	
Practical (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (20%) 10 Marks in Each Component	End Semester Examinations (ESE) (80% 40 Marks in Each Component)
04	2	20	80

Learning Objectives and Course Outcomes:
As per Courses USMAAS304 AND USMAAS305.

Module	Mathematics Practical 3	No of hours
PRACTICALS		60
Sr. No.	**Based on Course USMAAS304**.	
1	Semigroups and Monoids, Groups, Subgroups, Cyclic Groups.	
2	Homomorphism's, Cosets and Normal Subgroups.	
3	Permutation Functions, Rings and Fields.	
4	Boolean Expressions and Boolean Functions, Identities, Duality, Abstract Definition of a Boolean Algebra.	
5	Representation of Boolean functions, Functional Completeness, Logic Gates, Combination of Gates, Circuits, Adders, Minimization of Circuits. Karnaugh Maps, Don't Care Conditions, The Quine-McCluskey Method,	
6	Representation of Boolean functions, Functional Completeness, Logic Gates,	
7	Minimization of Circuits. Karnaugh Maps, Don't Care Conditions, The Quine-McCluskey Method.	
8	Languages and Grammars: Introduction, Phrase Structure Grammars with Types, Derivation Tress, Backus-Naur Form.	
9	Finite-State Machines with Output: Finite State Machines with Outputs and with No Output. Finite-State Automata, Language Recognition by Finite-State Machines Language Recognition: Kleene's Theorem, Regular Sets and Regular Grammars.	
10	Turing Machines, Computing Functions with Turing Machines, Different Types of Types of Turing Machines, The Church-Turing Thesis.	
Sr. No.	**Based on Course USMAAS305**.	
1	Matrices, Dot product and Matrix Multiplication.	
2	Solutions of Linear System of Equations, Inverse of a Matrix. LU- Factorization	

3	Applications: Markov Chains ; Linear Economic Models
4	Determinants, Cofactor Expansion and Applications.
5	Vectors in a plane.
6	Linear transformations.
7	Application in R2 and R3: Computer Graphics, Cross Product in R3, lines and Planes.
7	Vector Spaces, Subspaces.
8	Linear Independence, Basis and Dimensions.
9	Homogeneous Systems, Rank of a matrix, Coordinates and Change of Basis,
10	Orthonormal Bases in Rn, Orthogonal Complements. QR-factorization; Least Squares

Program: B.Sc.- Applied Statistics And Data Analytics (Honours)			Semester : III
Course: Python Practical 1 (Based on Course USMAAS306).			Course Code: USMAASP36
Teaching Scheme		Evaluation Scheme	
Practical (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (20%) 10 Marks	End Semester Examinations (ESE (80%) 40 Marks
02	1	10	40

Learning Objectives and Course Outcomes:
As per Course USMAAS306.

Module	Python Practical 1	No of hours
PRACTICALS		30

Sr. No.	Based on Course USMAAS306
1	Converting °C temperature to °F.
2	To carry out arithmetic calculations.
3	To check whether given number is odd or even.
4	To check whether given number m is divisible by n or not.
5	To find maximum of 2 numbers or 3 numbers, sum of digits of a number.
6	To find area of triangle and circle.
7	To find roots of quadratic equation.
8	To check whether integer is prime or not.
9	To find mean, Geometric mean and Harmonic Mean of n numbers.
10	To prepare multiplication table.
11	To solve simultaneous linear equations.(two equations in two variables)
12	To evaluate simple and compound interest
13	To solve transcendental equations using Newton-Raphson method.
14	To evaluate exp(x), sin (x), log (x) etc. using Taylor's series expansion.
15	To convert decimal number to equivalent binary number.
16	To generate Fibonacci series like 0, 1, 1,2,3,5…
17	To combine given two strings using string function.
18	To find factorial of integer number (both recursive and non-recursive)
19	To find the value of Xn where n is integer.(both recursive and non-recursive)
20	To find GCD of two integer numbers(both recursive and non-recursive)

21	To find maximum/minimum of n numbers.(non-recursive)
22	To obtain addition of two matrices, multiplication of two matrices.
23	To find mean, median, variance and coefficient of variation of frequency distribution.
24	To find correlation coefficient and line of best fit of Y on X (X on Y) for a given bivariate data.
25	To sort the given data in increasing/decreasing order of magnitude.
26	To obtain median of given n observations.
27	To test palindrome string using string function.
28	To sort a string using string function.
29	To search string using string function.
30	To check for pangrams. (A sentence which contains the alphabets at least once.)
31	To print the items in a list
32	To Check for Armstrong numbers
33	To write a recursive function to print the factorial.
34	To write a function which will reverse the value/ use defined value.
35	To Define a function that computes the length of a given list or string.
36	To sort (ascending and descending) a dictionary by value.
37	To concatenate dictionaries to create a new one.
38	To sum all the items in a dictionary.
39	To print a specified list after removing the 0th, 2nd, 4th and 5th elements.
40	To Write a Python program to clone or copy a list.
41	To Design a class that will store and display the information of a student.
42	to read an entire text file.
43	To append text to a file and display the text.
44	To read last n lines of a file.
45	Define a procedure histogram() that takes a list of integers and prints a histogram to the screen.

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : IV
Course: : Probability Distributions IV			Course Code: USMAAS401
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (TEE) (Marks-75 in Question Paper)
03	03	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 distribution is 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

1. definition of F-distribution
2. 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 chi square and t distribution.

ii) Understand sampling distributions and applications of the F distribution.

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 of freedom 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 probability distribution. iv) Compute probabilities using an exponential probability distribution		
Outline of Syllabus: (per session plan)		
Module	Description	No of hours
1	Standard Continuous Distributions II	15
2	Exact Sampling Distributions I (Chi Square and t)	15
3	Exact Sampling Distributions II (F distribution and Fishers Z transformation)	15
	Total	45
Module	Probability Distributions IV	No. of Hours/Credits 45/3
1	Standard Continuous Distributions II	15
	❖ 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 be discussed: ❖ Mean, Median, Mode, Mean absolute deviation & Standard deviation. Moment Generating 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. ❖ Central Limit theorem for i.i.d. random variables.	8 7
2	Exact Sampling Distributions : Chi Square & Students t	15
	Chi-Square Distribution: ❖ Concept of degrees of freedom. Mean, Median, Mode & Standard deviation. Confidence interval for the variance of a Normal population. ❖ 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). ❖ Application of Chi-square Distribution. 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	7 8

	freedom. Asymptotic properties. Student's t. ❖ Application of t-Distribution. ❖ Confidence interval for: Mean of Normal population; Difference between means of two independent Normal populations having the same variance.	
3	Exact Sampling Distributions: F, Interdependence of Normal, Chi-square, t, F distributions, Fisher's Z- transformation	15
	❖ 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. ❖ Applications of F- distribution. Fisher's Z- transformation and its application.	7 3 5

ESSENTIAL READINGS:

1. Ken Black, Business Statistics for Contemporary Decision Making, Wiley Plus,9th Edition.
2. Jay L. Devore, Probability and Statistics for Engineers and the Sciences, Cengage Learning, 9th edition.
3. Roxy Peck, Jay L. Devore, Statistics: The Exploration & Analysis of Data, Cengage Learning, 7th edition.

SUPPLEMENTARY READINGS:

1. A. M. Mood, F.A. Graybill, D. C. Boyes, Introduction to the theory of statistics, McGrawHill Book Company, 3rd Edition.
2. R.V.Hogg, A.T. Craig; Introduction to Mathematical Statistics: Collier McMillan Publishers
3. R.V.Hogg, E. A.Tannis, Probability and Statistical Inference: Collier McMillan Publishers
4. John E. Freund's I. Miller, M. Miller; Mathematical Statistics, Pearson Education Inc. 6th Ed.
5. P.G. Hoel; Introduction to Mathematical Statistics, John Wiley &Sons Inc. 4th Edition.
6. J. Medhi; Statistical Methods: An Introductory Text: 2nd Edition; Wiley Eastern Ltd.
7. S.C. Gupta, V.K. Kapoor; Fundamentals of Mathematical Statistics: 8th Ed. Sultan Chand & Sons.
8. A.M. Goon, M.K. Gupta, B. DasGupta; An Outline of Statistical Theory Vol. 1: 3rd Edition; The World Press Pvt. Ltd.
9 Goon A.M., Gupta M.K. and Das Gupta B. (1986): Fundamentals of Statistics, Vol.II, World Press, Calcutta.

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : IV
Course: *:* Design of Experiments			Course Code: USMAAS402
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

To make the learner aware of

- Understand what between-group and within-group variability consist of and represent.
- Understand the role of between-group and within-group variability in testing differences between group means.
- Understand what 'ANOVA' stands for, and why.
- Understand why, in testing the difference between means, the inferential statistic is called the F-ratio.
- Understand the characteristics of the theoretical distribution of F-ratios

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	15
2	CRD and RBD with and without interactions	15
3	Latin Square Design and Factorial Designs.	15
	Total	45
Module	Design of Experiments	No. of Hours/Credits 45/3
1	ANOVA	15
	❖ 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	6

	of squares- test, Analysis of variance table. ❖ Least square estimators of the parameters, Variance of the estimators, ❖ Estimation of treatment contrasts, Standard Error and Confidence limits for elementary treatment contrasts.	 5 4
2	Design Of Experiments, Completely Randomized design & Randomized Block Design.	15
	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 for elementary treatment contrasts. Efficiency of RBD relative to a CRD. Missing plot technique for one missing observation in case of CRD, RBD.	7 8
3	Latin Square Design, Factorial Experiments	15
	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 and Confidence 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. ❖ Confounding.	7 8

ESSENTIAL READINGS:

1. Dr. Parimal Mukhopadhyay, Applied Statistics: New Central Book Agency (P) Ltd. 2nd Edition (2001).
2. Douglas C Montgomery, Design and Analysis of Experiments, John Wiley & Sons. 6th Edition

SUPPLEMENTARY 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 Hill Book Company

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : IV
Course: Operations Research I			Course Code: USMAAS403
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

To make the learner

- Identify the special features of a model that make it a linear programming model.
- aware of the kinds of problems linear programming can be used to solve.
- Learn to formulate and solve linear programming models for simple problems.
- Aware of the concepts of allocation problems and to solve them.

Course Outcomes:

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

(CO1:Remember)

Know how to Formulate the LPP.

(CO2:Understand)

Conceptualize the feasible region for a given LPP.

(CO3:Apply)

Solve the LPP with two variables using graphical method.

Solve the LPP using simplex method.

Solve a linear programming with unrestricted-in-sign variables.

analyze small changes to a linear programming problem.

(CO4:Analyse)

Formulate the dual problem from primal.

Analyse the sensitivity of a decision variable.

(CO5:Evaluate)

Draw conclusion after solving a given allocation problem.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Linear Programming Problem	15
2	Integer Programming Problem , Sensitivity Analysis	15
3	Transportation Problem, Assignment Problem, Sequencing	15
	Total	45
Module	Operations Research I	No. of Hours/Credits 45/3
1	Linear Programming Problem (L.P.P.)	15
	Mathematical Formulation: Maximization & Minimization. Concepts of Solution, Feasible Solution, Basic Feasible Solution, Optimal solution. Graphical Solution for problems with two variables.	5

	Simplex method of solving problems with two or more variables. Big M method. Solution of LPP for unrestricted variables Concept of Duality. Its use in solving L.P.P. Relationship between optimum solutions to Primal and Dual. Dual simplex algorithm. Economic interpretation of Dual.	5 5
2	Integer programming problem (IPP) and Sensitivity analysis	15
	Integer programming problem (IPP): Introduction, solution of IPP using 1. Graphical method 2. Gomory's Method. Sensitivity Analysis: (Proofs are not expected) 1.Variation in the price vector "c". 2.Variation in requirement vector "b". 3.Addition of a new variable to the LPP.	7 8
3	Transportation Problem, Assignment Problem, Sequencing	15
	Transportation Problem: Concept, Mathematical Formulation. Concepts of Solution, Feasible Solution. Initial Basic Feasible Solution by North-West Corner Rule, Matrix Minima Method, Vogel's Approximation Method. Optimal Solution by MODI Method. Optimality test, Improvement procedure. Variants in Transportation Problem: Unbalanced, Maximization type. Assignment Problem: Concept. Mathematical Formulation Solution by: Complete Enumeration Method and Hungarian method. Variants in Assignment Problem: Unbalanced, Maximization type. Travelling Salesman Problem. Sequencing: Processing n Jobs through 2 Machines; Processing n Jobs through 3 Machines; Processing 2 Jobs through m Machines	7 4 3

ESSENTIAL READINGS:

1. Taha Hamdy A., Operations Research: Prentice Hall of India Pvt. Ltd., 10th edition.
2. S.D. Sharma, Operations Research, KedarNath Ram Nath & Company, 11th edition.
3. Richard Bronson, Schaum Series book in O.R., Tata McGraw Hill Publishing Company Ltd. 2nd edition,

SUPPLEMENTARY READINGS:

1. J. K. Sharma, (2001) Quantitative Techniques for Managerial Decisions, MacMillan India Ltd.
2. J K Sharma, (1989), Mathematical Models in Operations Research, Tata McGraw Hill Publishing Company Ltd.

3. Kantiswaroop and Manmohan, Gupta, Operations Research, 12th Edition, S Chand & Sons
4. Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), Operations Research: Methods and Problems, John Wiley & Sons.
5 Vora N. D. Quantitative Techniques in Management, 3rd edition, McGraw Hill Companies.
6. Banerjee B. Operation Research Techniques for Management, First edition, Business Books

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : IV
Course: Numerical Methods			Course Code: USMAAS404
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

- To provide the numerical methods of solving the non-linear equations, interpolation, differentiation, and integration.
- To improve the student's skills in numerical methods by using the numerical analysis software and computer facilities.
- To Understand Accuracy and precision with examples.
- To locate the roots of an equation using Graphical, Bisection and False Position methods.
- Understand one-point iterative method to find True roots.
- Learn methods like Newton Rapson's Method, Multiple Roots and Secant method.
- To find unknowns using Gauss Elimination method, Gauss Jordan method and Gauss Seidel method
- Understand the concept of regression method like Linear Regression, Polynomial Regression and Multiple Regression method to fit curve into straight line.
- To find inverse matrix using LU Decomposition method.
- To Learn Spline types like Linear, quadratic and cubical Spline

Course Outcomes:

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

(CO1: Remember)

The learner will know the difference between Accuracy and Precision and types of errors.

(CO2: Understand)

How to solve fixed point iteration method to obtain the true roots.

The methods of finding roots using Graphical method, Bisection method and False position method.

And other such methods.

The advantages and disadvantages of using different methods to compute the roots.

(CO3: Apply)

Solve a given expression using different methods learnt to compute the roots.

(CO4: Analyse)

Solve a Linear System of equation using Gauss Jordan and Gauss Seidel method.

(CO5: Evaluate)

Compute the roots using Graphical method, Bisection method False position method, True roots using Open method: Newton's Rapson method, secant method and multiple Newton Rapson method, Gauss Elimination Method.

Solve a regression methods fit a curves using linear regression, polynomial regression and Multiple regression method. To solve Linear spline, quadratic and cubical spline.

Outline of Syllabus: (per session plan)		
Module	Description	No of hours
1	Preliminaries, High Speed Computations, Transcendental and Polynomial Equations	15
2	System of Linear Algebraic Equations and Eigen Value Problems.	15
3	Interpolation and approximation, Curve Fitting.	15
	Total	45
Module	Numerical Analysis	No. of Hours/Credits 45/3
1	Preliminaries, High Speed Computations, Transcendental and Polynomial Equations.	15
	Binary Numbers, Error Analysis, Computer Arithmetic, Machine Computation and Flow Charts. Bisection Method, Iteration Methods Based on first degree and Second Degree equations. Rate of Convergence, General Iteration Methods. Methods of Complex Roots Polynomial equations/ approximations.	4 4 2 1 3
2	System of Linear Algebraic Equations and Eigen Value Problems	15
	Introduction, Direct Methods, Error Analysis for Direct Methods, Iteration Methods. Jacobi, Givens and Householders Methods for symmetric matrices. Rutishauser Method for Arbitrary matrices. Power method, Inverse Power Method.	5 4 3 3
3	Interpolation and Approximations, Curve Fitting.	15
	Introduction, Lagrange and Newton Interpolations. Finite Difference Operators. Interpolating Polynomials using Finite Differences. Interpolations: Hermite; Piecewise and Spline, Bivariate. Approximation, Least Square Approximation, Uniform Approximation, Rational Approximation.	4 4 4 3

ESSENTIAL READINGS:

1. M.K.Jain, S.R.K. Iyengar, R.K.Jain, Numerical Methods, New Age International Publishers, 7th edition.
2. John Mathews, Kurtis D. Fink, Numerical Methods using Matlab, Pearson. 4th edition.

SUPPLEMENTARY READINGS:

1. S.S. Sastry - Introductory methods of numerical analysis-, PHI Learning Pvt Ltd, 5th edition (2012).

2. E Balagurusamy, Numerical Methods, McGraw Hill Education 1 July 2017.
3. James F. Epperson An Introduction To Numerical Methods And Analysis 2nd Edition. (2013).
4. Mukherjee, Kr. Kalyan, Numerical Analysis. New Central Book Agency 2nd Edition, (2011

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : IV
Course: Linear Algebra 2			Course Code: USMAAS405
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

- To introduce the idea of eigenvalues and eigenvectors of a matrix to the learner.
- Use Linear Algebra in various scientific and mathematical applications.
- To make use of matrices to solve systems of linear equations; perform operations with matrices, calculate the inverse of a non-singular matrix, and calculate the determinant of a square matrix.
- Introduce the learner to the concept of a vector space and to perform vector operations; determine linear independence and find a spanning set of vectors.
- Introduce the learner to the concept of subspaces of a vector space and to determine a basis for a subspace and determine its dimension; find the subspaces associated with a matrix, and determine the rank and nullity of a matrix.
- To define a linear transformation and find the matrix associated with it; determine the kernel and range of a transformation; find the inverse of a transformation and the composition of two or more linear transformations; calculate the change of basis matrix.

Course Outcomes:

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

(CO1:Remember)

Eigenvalues and eigenvectors, diagonalizable matrices, systems of linear ordinary differential equations row/column space, vector spaces.

(CO2:Understand)

The method of solving a set of linear equation's, concepts of base, dimension, kernel, range. Matrix of linear transformation.

(CO3:Apply)

The knowledge of eigenvalues / vectors to a linear transformation.

(CO4:Analyse)

Solve a system of linear equations

(CO5:Evaluate)

Characteristic polynomial of a transformation matrix

Kernel and image spaces of a linear transformation

The algebra of matrices in order to solve applied and theoretical problems using inverses of matrices, determinants and other algebraic operation

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Eigenvalues, Eigenvectors and Diagonalization.	15
2	Linear Transformation and Matrices	15
3	Matlab For Linear Algebra	15
	Total	45

Module	Linear Algebra 2	No. of Hours/Credits 45/3
1	Eigenvalues, Eigenvectors and Diagonalization	15
	Eigenvalues and Eigenvectors. Diagonalization Applications: The Fibonacci Sequence, Differential Equations, Quadratics Forms, Comic Sections, Quadratics Surfaces.	
2	Linear Transformation and Matrices	15
	Definition and Linear transformation and Matrices. Examples. The Kernel and Range of a Linear Transformation. The Matrix of a Linear Transformation.	
3	Matlab For Linear Algebra	15
	MATLAB, Entering and Displaying a Matrix, Solving Systems of Linear Equations, Dot Product, Norm, Angle, Distance. Matrix Operations, Computational Considerations, Inverse of a Matrix Solving Systems of Equations Using Matrix Inverse, Cryptography, Transformations Defined by Matrices. Fractals, Leontief I/O Model, Markov Chains, Determinants, Cramer's Rule. Eigenvalues and Eigenvectors. Linear Combinations, Dependence, Basis, Rank. Projection, Gram-Schmidt Orthogonalization., QR Factorization Kernel and Range, Inner Product, Non-Euclidean Geometry. Space–Time Travel Pseudoinverse and Least Squares Curves. LU Decomposition. Condition Number of a Matrix. Jacobi and Gauss-Seidel Iterative Methods. Singular Value Decomposition. Cross Product. MATLAB Commands, Functions, and M-Files. The Linear Algebra with Applications Toolbox M-Files.	

ESSENTIAL READINGS:

1. Bernard Kolman David Hill, (2014), Elementary Linear Algebra with Applications, 9th Edition, Pearson.
2. Gareth Williams, (2019), Linear Algebra with Applications, 9th Edition, Jones and Bartlett Learning.

SUPPLEMENTARY READINGS:

1. Gilbert Strang, Introduction to Linear Algebra 5th Edition, Wellesley - Cambridge Press
2. Gilbert Strang, (2019) Linear Algebra and Learning from Data, Wellesley- Cambridge Press
3. Kenneth Kuttler, (2020), Linear Algebra, Theory and Applications. World Scientific.

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : IV
Course: Advanced R			Course Code: USMAAS406
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

To introduce the learner to the powerful software used for statistical calculations and data analysis.
To strengthen the knowledge and understanding of the R software.
To make the learner what makes R different and special from other languages.

Course Outcomes:

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

(CO1:Remember)
The difference between an object and its name
Learn what data structures are?
(CO2:Understand)
Why the difference between the object and its name is important.
Learn how a datastructures fits together.
The three most important OO systems S3,S4 and R6.
(CO3:Apply)
The learner will be able to use the fine detail of functions and environments.
The learner will know how to pull datastructures apart using subsetting.
To Learn the condition system which powers messages, warnings and errors.
(CO4:Analyse)
The powerful functional programming paradigm which can replace many loops.
(CO5:Evaluate)
How to find and remove performance bottlenecks.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Foundations and Functional Programming	15
2	Object Oriented Programming	15
3	Metaprogramming and Techniques	15
	Total	45
Module	Advanced R	No. of Hours/Credits 45/3
1	Foundations and Functional Programming	15
	Foundations: Names and Values, Vectors, subsetting, Control flow, Functions, Environments, Conditions. Vocabulary, Style guide.	6 9

	Functional Programming: Functional, Function Factories, Function Operators.	
2	Object Oriented Programming	15
	Introduction, Base types, S3, RC, R6 S4 , Trade-offs.	6 5 4
3	Metaprogramming and Techniques	15
	Metaprogramming: Introduction, Big picture, Expressions Techniques: Introduction, Debugging, Measuring and Improving performance.	8 7

ESSENTIAL READINGS:

1. Hadley Wickham, Advanced R-Taylor & Francis, (Chapman & Hall, CRC the R series (CRC Press) (2019) Ed.2.

SUPPLEMENTARY READINGS:

1. Hadley Wickham, Advanced R-Taylor & Francis, (Chapman & Hall, CRC the R series (CRC Press) (2015) Ed.1.
2. Hadley Wickham, Garrett Grolemund - R for Data Science_ Import, Tidy, Transform, Visualize, and Model Data-O'Reilly Media (2017)

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : IV
Course: Applied Component 4 : Basic Data Mining Concepts			Course Code: USMAAS407
Teaching Scheme	Evaluation Scheme		
Lecture (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks - 25)	End Semester Examination (ESE) (Marks-75 in Question Paper)
03	03	25	75

Learning Objectives:

- To introduce the learner to various data mining concepts and algorithms.
- To Emphasize the use of data mining concepts in real world applications with large data base components.
- To develop and apply critical thinking, problem-solving, and decision-making skills.

Course Outcomes:

After completion of the course, learners will:

CO1 : (Remember)

To use data mining principles and methods / techniques.

To use data mining as a cutting edge business intelligence method.

CO2 : (Understand)

Building basic terminology of data mining.

Build competitive advantage through proactive analysis, predictive modelling, and identifying new trends and behaviours.

CO3 : (Apply)

Collect large data sets of data.

To produce a quantitative analysis report/memo with the necessary information to make decisions.

CO4: (Analyse)

Analyze large sets of data to gain useful business understanding

Describing and demonstrating basic data mining algorithms, methods, and tools

CO5 : (Evaluate)

Make use of machine learning, pattern recognition, statistics, visualization, algorithm, database technology and high-performance computing in data mining applications

Learn more developing areas - web mining, text mining, and ethical aspects of data mining.

Outline of Syllabus: (per session plan)

Module	Description	No of hours
1	Introduction , Related Concepts.	15
2	Data Mining Techniques, Classification.	15
3	Clustering, Association Rules	15
	Total	45
Module	Applied Component 4 (Basic Data Mining Concepts)	No. of Hours/Credits 45/3
1	Introduction, Related Concepts.	15

	Basic Data Mining Tasks; Data Mining Versus Knowledge Discovery in Databases, Data Mining Issues, Data Mining Metrics, Social Implications of Data Mining, Data Mining from a Database Perspective. <u>Related Concepts:</u> Database/OLTP Systems, Fuzzy Sets and Fuzzy Logic, Information Retrieval, Decision Support Systems, Dimensional Modeling, Data Warehousing, OLAP, Web Search Engines, Statistics, Machine Learning, Pattern Matching.	5 5
2	Data Mining Techniques, Classification.	15
	<u>Data Mining Techniques:</u> A Statistical Perspective on Data Mining, Similarity Measures, Decision Trees, Neural Networks, Genetic Algorithms. <u>Classification:</u> Introduction, Statistical-Based Algorithms, Distance-Based Algorithms, Decision Tree-Based Algorithms, Neural Network-Based Algorithms, Rule-Based Algorithms, Combining Techniques.	5 5
3	Clustering, Association Rules.	15
	<u>Clustering:</u> Similarity and Distance Measures, Hierarchical Algorithms, Partitional Algorithms, Clustering Large Databases, Clustering with Categorical Attribute. <u>Association Rules:</u> Large Itemsets, Basic Algorithms, Parallel and Distributed Algorithms, Comparing Approaches, Incremental Rules, Advanced Association Rule Techniques, Measuring the Quality of Rules.	4 6

ESSENTIAL READINGS:

1. Margaret H. Dunham, Data Mining –Introductory and Advanced topics, Pearson (2006).

SUPPLEMENTARY READINGS:

1 Daniel T. Larose, Chantel D. Larose - Discovering Knowledge in data; An Introduction to Data Mining-Wiley, (Wiley Series on Methods and Applications in Data Mining) (2014).
2. Charu C. Aggarwal, Data Mining-The Textbook-Springer (2015).
3. Max Bramer, Principles of Data Mining, Springer, Verlag London, (2016).

Program: B.Sc.- Applied Statistics & Data Analytics (Honours)			Semester : IV
Course: Statistics Practical 4 (Based on Courses USMAAS401, USMAAS402 and USMAAS403).			Course Code: USMAAS4123
Teaching Scheme	Evaluation Scheme		
Practicals (Hours per week)	Credits	Continuous Assessment and Evaluation (CAE) (Marks – 20%)	End Semester Examination (ESE) (Marks-80% in Question Paper)
06	03	30	120

Learning Objectives and Course Outcomes:
As per Courses USMAAS401, USMAAS402 AND USMAAS403

Module	Probability Distributions III	No. of Hours/Credits 90/3

PRACTICALS	
Sr. No.	Based on Course USMAAS401.
1	Uniform and Triangular Distributions
2	Exponential , Gamma and Beta Distributions.
3	Normal Distribution I
4	Normal Distribution II
5	Fitting of Continuous Distributions
6	Chi-square distribution I
7	Chi-square distribution II
8	t- Distribution
9	F- Distribution
10	Fishers z transformation.
Sr. No.	Based on Course USMAAS402.
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 I
8	Factorial Experiments II
9	Factorial Experiments III
Sr. No.	Based on Course USMAAS403.
1	L.P.P. I - Formulation and Graphical Method.
2	L.P.P II – Simplex Method.
3	L.P.P III – Charnes Big M Method.
4	L.P.P IV Duality And Dual Simplex.

5	Integer Programming.
6	Sensitivity.
7	Transportation Problems.
8	Transportation Problems.
9	Assignment Problems
10	Sequencing

Program: B.Sc.- Applied Statistics And Data Analytics (Honours)			Semester : IV
Course: Mathematics Practical 4 (Based on Courses USMAAS404, and USMAAS405).			Course Code: USMAASP445
Teaching Scheme		Evaluation Scheme	
Practical (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE) (Marks – 20%) 10 Marks in Each Component	End Semester Examination (ESE) (Marks-80% in Question Paper)40 in Each Component)
04	2	20	80
Learning Objectives and Course Outcomes: As per Courses USMAAS404 AND USMAAS405.			

Module	Mathematics Practical 4	No of hours
PRACTICALS		60
Sr. No.	**Based on Course USMAAS404.**	
1	Binary Numbers and Error Analysis.	
2	Bisection Method, Iteration Methods Based on first degree and Second Degree	
3	Secant Method, Regula-Falsi Method, Newton Raphson Method Muller Method,	
4	General Iteration Methods.	
5	Methods of Complex Roots; Polynomial equations/ approximations.	
6	Direct Methods, Error Analysis for Direct Methods, Iteration Methods.	
7	Jacobi, Givens and Householders Methods for symmetric matrices. Rutishauser Method	
8	Lagrange and Newton Interpolations.	
9	Finite Difference Operators.	
10	Interpolations: Hermite; Piecewise and Spline, Bivariate.	
11	Approximation, Least Square Approximation, Uniform Approximation, Rational Approximation.	
Sr. No.	**Based on Course USMAAS405.**	
1	Computing and applications of Eigen values and Eigen vectors.	
2	Applications to Linear economic models, stable age distribution in a population.	
3	Diagonalization	
4	Applications of Eigenvalues and Vectors	
5	Application to Differential equations, Diffusion process	
6	Linear Transformations	
7	Kernel and Range of a linear transformation	
8	Matrix of a linear transformation	
9	Change of Basis theorem.,	

10	Diagonalizability Similarity, Orthogonal Matrices.

Program: B.Sc.- Applied Statistics And Data Analytics (Honours)	Semester : IV
Course: Advanced R Practical (Based on Courses USMAAS406).	Course Code: USMAASP46

Teaching Scheme		Evaluation Scheme	
Practical (Hours per week)	Credit	Continuous Assessment and Evaluation (CAE) (Marks – 20%) 10 Marks	Term End Examinations (TEE) (Marks-80% 40 marks
02	1	10	40

Learning Objectives and Course Outcomes:

As per Course USMAAS306.

Module	Advanced R Practical	No of hours
PRACTICALS		30

Sr. No.	Based on Course USMAAS406
1	Names and Values, Vectors, Subsetting
2	Control Flow, Functions, Environments, Conditions.
3	Functionals, Function Factories, Function Operators.
4	OOP : S3
5	OOP : S4
6	OOP : RC
7	OOP : R6
8	Metaprogramming : Coding and Evaluation.
9	Metaprogramming : Expressions
10	Metaprogramming : Evaluation, Translating R code : Latex.
11	Metaprogramming : Debugging, Measuring and improving performance.