Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

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

(Affiliated to Savitribai Phule Pune University, Pune)

National Education Policy (NEP)
Choice Based Credit System (CBCS)

Programme Skeleton and Syllabus of

M.Sc. Statistics

Implemented from

Academic Year 2023-24

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

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

(Affiliated to Savitribai Phule Pune University, Pune)

National Education Policy (NEP)
Choice Based Credit System (CBCS)

Programme Skeleton and Syllabus of

M.Sc. Statistics

Implemented from

Academic Year 2023-24

9.2 Distribution of credits

Type of Courses	Total Credits	Credits/ Semester
Discipline-Specific Core Courses (DSC)	54	14 /12
Discipline Specific Elective Courses (DSE)	16	04
Research Methodology (RM)	04	Semester I only
On-Job Training/ Internship (OJT/I	04	Semester II only
Project (PR)	10	Semesters III and IV only
Total	88	22

9.3 Master of Science (M.Sc.) Course Distribution

Class	Semester	Subjects	Courses	DSC		DSE		RM/OJT/ Internship etc.		Project *	Total Credits
				T	P	T	P	T	P		
M. Sc. I	I	01	09	03	03	01	01	01*		00	22
M. Sc. I	II	01	09	03	03	01	01	00	01	00	22
M. Sc. II	III	01	07	02	02	01	01	00	00	01	22
M. Sc. II	IV	01	07	02	02	01	01	00	00	01	22

* RM: Theory and Practical credits in RM paper shall be decided by the Department. The final marks/grade point shall be calculated by considering theory and practical marks.

9.4 Master of Science (M. Sc.) Credit Distribution

Class	Semester	Subjects	Courses	DSC		DSE		RM/OJT/ Internship etc.		Project *	Total Credits
				T	P	T	P	T	P		
M. Sc. I	I	01	09	08	06	02	02	04*		00	22
M. Sc. I	II	01	09	08	06	02	02	00	04	00	22
Exit Option: PG Diploma											
M. Sc. II	III	01	07	08	06	02	02	00	00	04	22
M. Sc. II	IV	01	07	08	04	02	02	00	00	06	22
				32	**20**	**08**	**08**	**02**	**06**	**12**	**88**

9.5 Master of Science (M. Sc.) Distribution of Courses

Class	Semester	Course and their credits in the bracket			
		DSC	DSE	RM/OJT/ Internship etc.	Project *
M. Sc. I	I	DSC -01 (03)	DSE -01 (02)	RM-01(04)	NA
M. Sc. I	I	DSC -02 (03)	DSE -02 (02)		
M. Sc. I	I	DSC -03 (02)			
M. Sc. I	I	DSC -04 (02)			
M. Sc. I	I	DSC -05 (02)			
M. Sc. I	I	DSC -06 (02)			
M. Sc. I	II	DSC -07 (03)	DSE -03 (02)	OJT-01 (04)	NA
M. Sc. I	II	DSC -08 (03)	DSE -04 (02)		
M. Sc. I	II	DSC -09 (02)			
M. Sc. I	II	DSC -10 (02)			
M. Sc. I	II	DSC -11 (02)			
M. Sc. I	II	DSC -12 (02)			
M. Sc. II	III	DSC -13 (04)	DSE -05 (02)	NA	PR-01(04)
M. Sc. II	III	DSC -14 (04)	DSE -06 (02)		
M. Sc. II	III	DSC -15 (03)			
M. Sc. II	III	DSC -16 (03)			
M. Sc. II	IV	DSC -17 (04)	DSE -05 (02)	NA	PR-02(06)
M. Sc. II	IV	DSC -18(04)	DSE -06 (02)		
M. Sc. II	IV	DSC -19 (02)			
M. Sc. II	IV	DSC -20 (02)			

Programme Framework (Courses and Credits): M. Sc. Statistics

Sr. No.	Year	Semester	Level	Course Type	Course Code	Title	Credits
1.	I	I	6.0	DSC-01	MS-ST111T	Linear Algebra	03
2.	I	I	6.0	DSC-02	MS-ST112T	Probability Distributions	03
3.	I	I	6.0	DSC-03	MS-ST113T	Sampling Theory and Methods	02
4.	I	I	6.0	DSC-04	MS-ST114P	Practical -I (Based on MS-ST111T)	02
5.	I	I	6.0	DSC-05	MS-ST115P	Practical -II (Based on Reliability Theory)	02
6.	I	I	6.0	DSC-06	MS-ST116P	Practical -III (Based on MS-ST113T)	02
7.	I	I	6.0	DSE-01	MS-ST117T	Exploratory Multivariate Analysis / Data Mining	02
8.	I	I	6.0	DSE-02	MS-ST118P	Practical IV (Based on MS-ST117 T)	02
9.	I	I	6.0	RM-01	MS-ST119T/P	Research Methodology	04

10.	I	II	6.0	DSC-07	MS-ST121T	Statistical Inference	03
11.	I	II	6.0	DSC-08	MS-ST122T	Regression Analysis	03
12.	I	II	6.0	DSC-09	MS-ST123T	Probability Theory	02
13.	I	II	6.0	DSC-10	MS-ST124P	Practical-V (Based on Statistical Process Control and Product control)	02
14.	I	II	6.0	DSC-11	MS-ST125P	Practical- VI (Based on MS-ST122)	02
15.	I	II	6.0	DSC-12	MS-ST126P	Practical- VII (Based on Numerical Analysis)	02
16.	I	II	6.0	DSE-03	MS-ST127T	Inferential Multivariate Analysis /Categorical Data Analysis	02
17.	I	II	6.0	DSE-04	MS-ST128P	Practical- VIII (Based on MS-ST127)	02
18.	I	II	6.0	OJT-01	MS-ST129P	On Job Training	04
19.	II	III	6.5	DSC-13	MS-ST131T	Stochastic Process	04
20.	II	III	6.5	DSC-14	MS-ST132T	Survival Analysis	04
21.	II	III	6.5	DSC-15	MS-ST133P	Practical - IX (Based on MS-ST131T, 132T)	03
22.	II	III	6.5	DSC-16	MS-ST134P	Practical - X (Machine Learning)	03
23.	II	III	6.5	DSE-05	MS-ST135T	Time Series Analysis	02
24.	II	III	6.5	DSE-06	MS-ST136P	Practical - XI (Based on MS-ST135)	02
25.	II	III	6.5	PR-01	MS-ST137P	Project	04
26.	II	IV	6.5	DSC-17	MS-ST141T	Design and Analysis of Experiment	04
27.	II	IV	6.5	DSC-18	MS-ST142T	Applications of Statistics in Clinical Trials	04
28.	II	IV	6.5	DSC-19	MS-ST143P	Practical XII (Based on MS-ST141, 142)	02
29.	II	IV	6.5	DSC-20	MS-ST144P	Practical XIII (Based on Modeling and Simulation)	02
30.	II	IV	6.5	DSE-07	MS-ST145T	Bayesian Inference	02
31.	II	IV	6.5	DSE-08	MS-ST146P	Practical XIV (Based on MS-ST 145 and SQL)	02
32.	II	IV	6.5	PR-02	MS-ST147P	Project	06

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

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

Board of Studies in Statistics

Sr. No.	Name	Designation
1.	Dr. A. A. Kulkarni	Chairman
2.	Dr. S.D Jagtap	Member
3.	Dr. B.P. Thakur	Member
4.	Prof. S.A Tarate	Member
5.	Dr.N.T Shelke	Member
6.	Dr. A.K. Khamborkar	Academic Council Nominee
7.	Dr. A.J. Shivagaje	Academic Council Nominee
8.	Prof. S. Kawale	Vice-Chancellor Nominee
9.	Dr. S.B.Pathare	Alumni
10.	Mr. Anirudha Deshmukh	Industry Expert
11.	Dr. Vijay Narkhede	**Invittee Member**
12.	Dr. B.K. Thorve	**Member**
13.	Prof. K.B. Mane	**Member**

1. Prologue/ Introduction of the programme:

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

M.Sc. in Statistics program is of two years' duration, with semester pattern. The important feature of the syllabus is that, all practical's form first year second year will be conducted on computer using R, Python SciLab, SPSS, ITSM programming and Tableau.

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

2. Programme outcomes (PoS)

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

I. Student will achieve the skill of understanding the big data handling

II. Student will have skill to write a story using data visualization.

III. Student will understand the interdisciplinary approach to correlate the statistical concepts with concepts in other subjects.

IV. Students will get good and unique combination of statistical concepts with computational tools which they use in feature

V. Student will be handle the real life example and industrial problems in project

VI. Students will demonstrate conceptual domain knowledge of the Statistics in an integrated manner.

VII. Student will get sufficient knowledge to compete in any examination with great zeal like (NET / SET, UPSC, MPSC) etc.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Linear Algebra								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-1	MS-ST111T	03	00	03	45	30	70	100

Learning Objectives:

1. The main objective of this course is to develop theoretical as well as working knowledge of the central ideas of linear algebra.
2. To learn the concept of vector space, inner space and its properties.
3. To learn the concept of generalized inverse and its importance.
4. To learn various methods to solve system of linear equations.
5. To study the various Matrix operations and its properties to handle various problems in Statistics.

Course Outcomes (Cos):

1. Student able to handle computational techniques and algebraic skills.
2. Critically analyze and construct mathematical arguments that relate to the study of introductory linear algebra.
3. Knowledge of algebra will help the students in the different fields, such as ML, Data Science, Multivariate, Regression Analysis and especially for Deep Learning.
4. After completing this course, students shall bear a good insight to study general plus advanced contents of the above-mentioned courses

Detailed Syllabus:

Unit-I	**Vector and Inner Product Space**	15
	Vector Space & Subspace: Linear dependence and independence, Basis of vector space, dimension of vector space, properties and uses of a basis. orthogonal and orthonormal basis, Algebra of Matrices: special types of matrices, rank, inverse and determinant of a matrix and their properties, Orthogonal and idempotent matrix and their properties.	
	Inner Product Spaces: Projection theorem, linear transformation, linear equations, Solution space and null Space, dual of a Vector, Null Spaces and Range, Null Space and Injectivity and Surjectivity, Gram –Schmidt orthogonalization.	
Unit II	**Generalized Inverse and System of linear equations**	15

	Generalized (g) inverse and Moore-Penrose g- inverse (MP g-inverse), Properties of (g) inverse and (MP g-inverse) and its Examples, Existence of MP g-inverse, g-inverse and system of linear equation, Methods to obtain g & MP g – inverse.	
	System of homogeneous and non- homogeneous linear equations, Elementary row transformation, Gauss Elimination, Gauss–Jordan Elimination (matrix inversion), Gauss Seidel, Gauss Jacobi iteration, LU Decomposition method, Consistency and inconsistency of system of linear equation, solution space and null Space.	
Unit III	**Characteristic roots , Vectors and its applications**	10
	Characteristic roots (eigen values or Latent roots) of real matrices, right and left characteristics vectors (eigen vectors), Independence of characteristics vectors corresponding to distinct characteristic roots, algebraic and geometric multiplicity.	
	Spectral decomposition, power of a matrix, Cayley Hamilton theorem, singular value decomposition, trace inequalities, eigen-value inequalities, invariant subspaces, eigen spaces, real Spectral decomposition theorem, characteristic and minimal polynomials.	
	Fast direct solution of a large linear system, applications large scale eigen value problems, derivatives with respect to vectors and matrices LU factorization, Cholesky factorization.	
Unit IV	**Quadratic forms**	5
	Introduction of quadratic forms (QF), reduction and classification of a quadratic form, simultaneous reduction of two quadratic forms, maxima and minima of a quadratic form, properties of a quadratic form for orthogonal and idempotent matrices.	

Suggested Readings/Material:

1. Peter J. Olver · Chehrzad Shakiban, Applied Linear Algebra Second Edition, Springer
2. Jörg Liesen, Volker Mehrmann, Linear Algebra, Springer Undergraduate Mathematics Series
3. Linear Algebra, Done Right,Sheldon Axler,Third Edition, Springer
4. Bapat, R.B. (2011). Linear Algebra and Linear Models. Springer and Hindustan Book Agency.
5. Beezer, R. A. (2004). A First Course in Linear Algebra, Congruent Press, Washigton.
6. Hohn, F. E. (1973). Elements of Matrix Algebra, Macmillan.
7. T. and Rosen, D. von (2005). Advanced Multivariate Statistics with Matrices, Springer, New York.
8. Kollo5. Kumaresan, S. (2000). Linear Algebra: A Geometric Approach, Prentice Hall
9. Lay, D. C. Lay, S. R. and Mc Donald, J. J. (2016). Linear Algebra and Its Applications, Fifth Edition, Pearson, Boston.
10. Scilab Textbook Companion for Linear Algebra and Its Applications by D. C. Lay.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Probability Distributions								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-2	MS-ST112T	03	00	03	45	30	70	100

Learning Objectives:

1. To train in general theory of probability distributions.
2. To study the different characteristic peoperties of ramdom variable.
3. Insight the important Bivatiate Probability Distributions and its application to solve the real life problems.
4. To discuss the application of quadratic form and its application in field of sampling distributions.
5. To learn some non-central distribution and its real life applicationas.

Course Outcomes (Cos)

1. Students can derive theoretical results of various probability distributions which is a pre-requisite for inference.
2. Students will be developed problem solving techniques to calculate bivariate probabilities.
3. Students should be able apply probability distributions in real life problems.

Detailed Syllabus: Example

Unit-I	**Charectristic Properties of Random variable**	15
	Cumulative Distribution function(CDF): CDF of random variable, continuity theorem of limit of probability, characteristic properties of CDF, Decomposition of CDF, mixture of distributions, identification of given function whether it is CDF. Proofs of the following results: i. Product of distribution function is CDF ii. If F(.) is a CDF then $F^n(.)$, $1-(1-F(.))^n$ are CDF for n positive integer. iii. Convex combination of CDFs is CDF. Bivariate random variable: CDF of bivariate random variable and its characteristic properties. Identification of given function whether it is CDF.	
	Symmetry: Symmetric probability distribution around a, concept of mean median, mode need not coincide for symmetric probability distribution with illustation. Following results with proof: i. All odd ordered central moments of symmetric distribution are zero.	

	ii. Sum and difference of random variables with symmetric distribution is symmetric. iii. Second quartile of the symmetric distribution is equidistance from the first and third quartile.	
	MGF:Definition, Existence of MGF, properties of MGF, MGF of symmetric distributions, deduction of raw and central moments from the MGF, applications of MGF. PGF: Definition, properties, moments using PGF, probability distributions of X+Y, X-Y when X and Y are not identically distributed random variables. Compound distribution and its PGF, application of PGF in Wald's , Var $(X_1+X_2+ - - - + X_N)$. Following results with proof: (i) If $P_1(s)$ and $P_2(s)$ are PGF of independent r.v.s then $P_1(s) * P_2(s)$ is a PGF (ii) $P_1(P_2(s))$ is PGF (iii) $[P_1(s)]^n$ is a PGF n positive integer. (iv) Px(s)= P-x(s) if X is symmetric around zero. Convolutions of random variables. Distributions of X+Y, X-Y in case of U (0, 1), Normal, exponential etc. Characteristic function: characteristic function and properties, conjugate pairs of distributions, Parseval relation, uniqueness theorem.	
Unit-II	**Bivariate Poisson Distributions**	10
	Bivariate Poisson random variable: If Y_1, Y_2 and Y_3 are independent Poisson random variable with parameters $\theta_1, \theta_2, and\ \theta_{12}$ respectively. Let $X_1 = Y_1+Y_3$ and $X_2=Y_2+Y_3$ then (X_1, X_2) is Bivariate Poisson random variable and has Bivariate Poisson Distribution with parameters $(\theta_1, \theta_2, \theta_{12}) \in R^{3+}$ Statement and Derivation of Joint PMF of Bivariate Poisson Distribution: $P(x1,x2) = e^{-(\theta_1+\theta_2+\theta_{12})} \sum_{i=0}^{\min(x1,x2)} \frac{{\theta_1}^{x1-i}\ {\theta_2}^{x2-i}\ {\theta_{12}}^{i}}{(x2-i)!(x2-i)!i1!}$, Where $x_1 \in W$ and $x_2 \in W$ where W : set of Whole number. Interpretation of Parameters. Marginal Distribution, Expectation, Variance, Joint MGF, Joint PGF and Joint CGF, Raw moments using MGF, central moments using CGF, Covariance, Variance-Covariance Matrix, rank of Variance-Covariance Matrix, correlation matrix, Conditional Distribution, Conditional mean and conditional variance. Applications and numerical examples.	
Unit-III	**Bivariate Exponential Distribution**	8
	Bivariate Exponential Distribution: Marshall –Olkin model: Joint distribution, Marginal Distribution, Lack of Memory Property, Properties of Marshall –Olkin model.	
	Freund's Bivariate Distribution (Bivariate Exponential Extension-BEE): joint density, Cumulative Distribution Function, Univariate Properties, Correlation coefficient, Conditional properties, Joint Moment Generating Function, Other properties	

	Gumbel's Bivariate Exponential Model Theorem: Gumbel's Type I Bivariate exponential distribution, Characterizations, Estimation method, Other properties, Gumbel's Type II Bivariate exponential distribution,	
Unit-IV	**Order Statistics, Quadratic Forms & Non-central distributions**	12
	Order Statistics: Definition, Marginal pdf of $X_{(r)}$, Joint pdf of $(X_{(r)}, X_{(s)})$, PDF of sample range ,corr $(X_{(r)}, X_{(s)})$, when random sample from U(0,1), problems based on exponential, distributions of spacing and standardized spacing.	
	Quadratic Forms: Quadratic forms, classification of quadratic forms, sampling distribution of quadratic forms and linear forms for random sample from normal distribution, distribution of quadratic forms. all result require for Fisher Cochran theorem, Fisher Cochran theorem.	
	Non-central distributions: (i) Non-central chi-square distribution, derivation of pdf, mgf, mean, variance, applications. (ii) Non-central t-distribution, derivation of pdf, mgf, mean, variance, applications. (iii) Non-central F- distribution, derivation of pdf, mgf, mean, variance, applications.	

Suggested Readings/Material:

1. Balakrishnan, Chin-Diew Lai, Discrete Bivariate Distributions, Springer.
2. N. Balakrishnan, Chin-Diew Lai, Continuos Bivariate Distributions, Springer.
3. Berger, R. and Casella G. (2002). Statistical Inference, Duxbury Resource Center, Second Edition.
4. Dasgupta, A. (2010) Fundamentals of Probability: A First Course, Springer, New York.
5. Hogg, R. V. McKean, J. W. and Craig, T. T. (2005). Introduction to Mathematical Statistics, Sixth Edition, Pearson Prentice Hall, New Jersey.
6. Rao, C. R. (2002). Linear Statistical Inference and Its Applications, Wiley.
7. Rohatgi, V. K. & A. K. M. E Saleh (2001). Introduction to Probability and Statistics, Wiley, New York.
8. Kale, B.K. & Muralidharan, K. (2015) Parametric Inference: An Introduction, Alpha Science International Ltd.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Sampling Theory and Methods								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-3	MS-ST113T	02	00	02	30	15	35	50

Learning Objectives:

1. To learn scientific way to conduct the survey in proper way.
2. To study different Random and Non-random sampling techniques.
3. To learn methods of estimation for various sampling techniques.
4. To compare the different sampling techniques.

Course Outcomes (Cos)

1. The main objective of this course is to provide the knowledge of concept of sample and population in statistics and also elaborate in department knowledge of sampling schemes and estimation of population parameters.
2. The student must be able to o use different sampling techniques. construct strata, able to do deep stratification, post stratification, use Horvitz Thompson estimator to estimate parameters
3. Use of double sampling scheme, PPS sampling
4. Understand non-sampling errors
5. Use some estimation techniques with special reference to non-response problems

Detailed Syllabus:

Unit-I		**Basic concepts of Sampling**	7
		Basic finite population techniques SRSWR, SRSWOR Inclusion probabilities, related results on estimation of population total, confidence limits, Determination of sample size for pre-specified variance, pre-specified error in the estimation, pre-specified width of the confidence interval, pre-specified relative error in the estimation	
		Simple random sampling for the proportion, Estimation of proportion for the more than two classes, Inverse Sampling (Sampling for the rare attribute) and estimator of the population mean and its variance.	
Unit-II		**PPS Sampling and Stratified Random Sampling**	8
		Probability Proportional to Size with Replacement (PPSWR) methods, cumulative total method and Lahiri's method for estimation problem, estimation of finite population mean and total, Sampling with varying probability without replacement, Horwitz–Thompson estimator, its variance and properties, midzuno scheme of sampling	

		Stratified sampling, comparison of allocation problem of allocation in stratified sampling, construction of strata, deep stratification. Post stratification, estimator of population means and variance of estimator of population mean under post stratification.	
Unit-III		**Ratio and Regression Method of Estimation**	8
		Use of supplementary information for estimation, ratio estimator of population mean, its bias and mean square error, unbiased ratio type estimators of population mean, variance of estimator of population mean under it, Jack-Knife estimator of population mean, ratio estimator for the stratified random Sampling.	
		Regression method of estimation, estimator of population mean, its bias and mean square error of the Estimator, comparison of estimator of population mean under ratio, regression and simple random sampling	
Unit-IV		**Two phase and Systematic Random Sampling**	7
		Two phase sampling, ratio and regression estimator of population mean under two phase sampling, bias in the estimator and its MSE	
		Systematic sampling, sample mean and its variance, Yates corrected estimator, Centered systematic sampling, Balanced systematic sampling and Modified systematic sampling, circular systematic sampling, two dimensional systematic sampling (Aligned and Unaligned Systematic sampling), comparison of systematic sampling with random sampling and stratified sampling .	

Suggested Readings/Material:

1) Cochran, W.G: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
2) Sukhatme, P.V., Sukhatme, B.V. and Ashok A.: Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.
3) Murthy, M.N: Sampling Methods, Indian Statistical Institute, Kolkata.
4) Daroga Singh and Choudhary F.S.; Theory and Analysis of Sample Survey Designs, Wiley EasternLtd., New Delhi.
5) Mukhopadhay, Parimal: Theory and Methods of Survey Sampling, Prentice Hall
6) R.S. Rao, Chapman: Sampling methodologies and applications and Hall/CRC 2000
7) Elements of sampling theory and methods: Z. Govindrajalu,Prentice Hall, 1999

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Practical -I (Based on MS-ST111T and MS-ST112T)								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-4	MS-ST114P	00	02	02	60	15	35	50

List of Practical:

Sr. No.	**Title of the Practical**	No. of Practical's
1	Matrices: Properties of Matrices (rank, inverse, transpose, determinant), Getting vectors in row/column space and null space of the given matrix.	2
2	Eigen values and Eigen vectors of a matrix, algebraic and geometric multiplicity of an Eigen value, etc. Computing power of a given matrix using spectral decomposition.	2
3	Inverse of a square matrix (by direct method and partitioning method), g-inverse, MP g- inverse.	2
4	Gram-Schmidt orthonormalization: Forming an orthogonal matrix of specified order using Gram-Schmidt orthogonalization.	1
5	Solution of System of Linear Equations using Gauss elimination, Gauss Jorden, Gauss- Seidal and Gauss Jacobbi methods.	2
6	Classification and Reduction of Quadratic forms, Verification of Cayley-Hamilton theorem	2
7	Practical on LU Factorization and Cholesky factorization.	1
8	Probability computation of different Bivariate Distributions	1
9	Application of Quadratic Form & Order Statistics.	2
	Total	**14**

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Practical -II (Based on Reliability Theory)								
Year: I				Semester: I				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-5	MS-ST115P	00	02	02	60	15	35	50

Learning Objectives:

1. To study the concept of Coherent system and its properties.
2. To learn different ways to represent the coherent system graphically.
3. To study reliability analysis of the coherent system**.**

Course Outcomes (Cos)

1. Students will able to study different properties of non-repairable system.
2. After completion of this course, students can solve different industrial problems related to reliability.
3. Students will understand difference between component redundancy and system redundancy.
4. Students will able to analyse the system in terms of components and reliability importance.

List of Practical:

Sr. No.	**Title of the Practical**	No. of Practical's
1	Construvtion of R.B.D. for the different types of Coherent Systems	2
2	Dual of the coherent system,	2
3	Path Vector, Path Set, Minimal Path Vector and Minimal Path Set of different Coherent Systems and representation of system using Miminal Cut set	2
4	Cut Vector, Cut Set, Minmal Cut Vector and Minimal Cut Set of different Coherent Systems and representation of system using Miminal Cut set	2
3	System and Component Redundancy	1
4	Relative and Structural Imporetance of the component	2
5	Computation of the reliability of Coherent System	1
6	Fault –Tree Diagram	2
	Total	**14**

Suggested Readings/Material:

1. Meeker William and Escobar Luis (1998). Statistical Methods for Reliability Data, Wiley Interscience Publication, John Wiley & Sons.
2. Barlow R. E. and Proschan, Frank (1981). Statistical Theory of Reliability and Life Testing, Holt Rinebart and Winston Inc., New York.
3. Sinha, S. K. (1987). Reliability and Life testing, Second Edition, Wiley.
4. Trivedi, R.S. (2001). Probability and Statistics with Reliability, Queuing and Computer Science Applications, Prentice - Hall of India Pvt. Ltd., New Delhi.
5. Besterfield, D.H. and Michna, C.B. et al. (2009). Total Quality Management, 3rd edition, Pearson Education, Delhi.34.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Practical –II (Based on MS-ST113T)								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-6	MS-ST116P	00	02	02	60	15	35	50

List of Practical:

Sr. No.	**Title of the Practical**	No. of Practical's
1	Practical based on unequal probability sampling.	2
2	Determination of Sample Size	1
3	Simple Random Sampling for Proportion	1
4	Practical based on Inverse Sampling	1
5	Stratified Random Sampling for i)Post stratification ii) Deep stratification iii) Stratified random sampling for proportion	2
6	Practical based on Systematic sampling	2
7	Practical based on Ratio method of estimation	1
8	Practical based on Regression method of estimation	1
9	Practical based Two Phase and Multi Phase sampling	1
10	Survey Sampling	2
	Total	**14**

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Exploratory Multivariate Analysis								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSE-1	MS-ST117T	02	00	02	30	15	35	50

Learning Objectives:

1. To learn and develop scientific view to deal with multidimensional datasets.
2. Understand the extensions of univariate techniques to multivariate frameworks.
3. To learn to apply dimension reduction techniques used in the data analysis.
4. To learn different classification tools.

Course Outcomes (Cos):

1. The aim of this course is to build confidence in the students in analyzing and interpreting multivariate data.
2. Students will get idea to visualize multivariate data.
3. Providing guidelines to identify and describe real life problems so that relevant data can be collected.
4. Students will develop the procedure for estimating parameters of a model developed,
5. Students will handle big data and their interpretation by using suitable software.
6. Interpreting model results in real life problem solving, and Providing procedures for model validation.

Detailed Syllabus:

Unit-I	**Exploratory Multivariate Analysis**	5
	Exploratory multivariate Data Analysis: Concept of multivariate data and its dimensionality, population mean vector, Sample mean vector, Dispersion Matrix (Variance- Covariance Matrix), Correlation Matrix, difference between dispersion and Correlation matrix, Linear transformation of r.v. and its mean and variance, graphical representation by using scatterplot matrix, Enhanced Scatter plot and Bubble plot.	
Unit-II	**Principal Component Analysis**	10
	Principal Component Analysis: Concept of Principal Component (PC), population Principal component, principal components based on covariance, correlation and standardized variables, Summarizing sample variations by principal components- number of principal components. Interpretation of sample principal components, standardizing the sample PC. Graphical Representation of principal components- QQ plot, scatter plot, Scree plot and score plot	

	Factor Analysis: Orthogonal factor models, methods of estimating factors- PC method, ML method, large sample test for number of common factors, factor rotations: varimax, quartimax, equimax and promax method, factor scores- the weighted least square method and regression method, factor loadings, as well as various approaches to estimation of "communalities"	
Unit-III	**Cluster Analysis**	9
	Similarity measures, distances and similarity coefficients for pair of items, similarity and associations measures for the pair of variables. Hierarchical clustering methods- Agglomerative, Single, complete, average, Ward's linkage and Non-hierarchical- K- mean clustering method, qualitative method clustering, clustering based on statistical models. Correspondence Analysis: correspondence analysis, algebra of development of correspondence analysis and inertia.	
Unit-IV	**Canonical Correlation**	6
	Canonical variates and Canonical Correlation, interpretation of canonical variables, identifying the canonical variables, canonical correlation as generalization of others correlation coefficients, the first $'k'$ canonical variables as summary of variability, geometrical interpretation of canonical correlation analysis, sample canonical variates and sample canonical correlations, Canonical correlation analysis (CCA), methods of computing the first set of 'k' canonical variates and their canonical correlation, and methods of computing a set of ordered canonical variates, the k^{th} set of variates constrained to be orthogonal to the first *(k-1)* with real life example	

Suggested Readings/Material:

1. Anderson T.W. (1983): An Introduction to Multivariate Statistical Analysis (Second Edition) Wiley.
2. Johnson, R. and Wychern (1992): Applied Multivariate Statistical Analysis, prentice- Hall, 3rd. Ed
3. Giri, N.C. (1977): Multivariate Statistical Inference. Academic Press.
4. Khsirsagar A.M. (1972): Multivariate Analysis. Marcel Dekker.
5. Morrison, D.F. (1976): Multivariate Statistical Methods. 2nd. Ed. McGRAW Hill.
6. Muirhead, R.J. (1982) Aspects of Multivariate Statistical Theory, J.Willey.
7. Seber, G.A.F. (1984): Multivariate Observations. Wiley
8. Sharma, S. (1996): Applied Multivariate Techniques. Wiley.
9. Srivastava M.S. & Khatri C.G. (1979): An Introduction to Multivariate Statistics. North Holland.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Data Mining								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSE-1	MS-ST117T	02	00	02	30	15	35	50

Learning Objectives:

1. To understand the concept of data mining for enterprising data managment and as cutting edge technology tool.
2. To identify data sources, processing and imparting knowledge tools to analyse sets of data to gain useful business understanding.
3. To learn to apply classification techniques on appropriate data.
4. To learn different methods of extraction and text mining.

Course Outcomes (Cos)

After completion of this course

1. Students will understand the concepts related to supervised and unsupervised. learning methods and their applications.
2. Students will get the knowledge about the concepts of feature selection and extraction methods.
3. They will understand the appropriate models in data mining.
4. They will get knowledge related to SVM, Neural Networks, clustering etc.
5. Students will able to understand the concepts related to text mining and Understand and apply them in various contexts.
6.

Detailed Syllabus:

Unit-I		**Supervised Learning**	5
		Supervised Learning: K - nearest neighbourhood algorithm, Decision trees, Naïve Bayes and Bayesian networks.	
Unit-II		**Support-Vector Machines and Kernel Methods**	10
		Support-Vector Machines and Kernel Methods, Optimal Separating Hyperplane, Soft-Margin Classifier, SVM Criterion as Loss Plus Penalty, Computations and the Kernel Trick, Function Fitting Using Kernels, Kernel Smoothing and Local Regression, Model evaluation techniques, Cost-Benefit analysis using data driven costs	
Unit III		**Unsupervised Learning**	
		Unsupervised Learning: Hierarchical and k-means clustering, Kohonen networks, BIRCH clustering, Measuring cluster goodness Graphical evaluation of classification, Association rules, Genetic algorithms, Imputation of missing data.	9
Unit-IV		**Neural Network**	6

		Neural Networks and the Handwritten Digit Problem, Fitting a Neural Network, Autoencoders, Deep Learning, Learning a Deep Network	

Suggested Readings/Material:

1. Alpaydin, E. (2014), Introduction to Machine Learning, 3rd Ed. MIT Press.
2. Breiman, L., Friedman, J.H., Olshen, R.A. and Stone, C.J. (1984). Classification and Regression Trees. Wadsworth and Brooks.
3. Hastie T., Tibshirani R. and Friedman J. H., (2008). The Elements of Statistical Learning: Data Mining, Inference and Prediction. Springer.
4. James G., Witten, D., Hastie, T. Tibshirani, R. (2013). An Introduction to Statistical Learning: With Applications in R, Springer
5. Larose, D. T. and Laros, C. (2015). Data Mining and Predictive Analytics. Wiley.
6. Mohammad J. Zaki and Wagner Meira. (2014). Data Mining and Analysis. Fundamental Concepts and Algorithms. Cambridge University Press, New York.
7. Ripley,vB. D. (1996). Pattern Recognition and Neural Networks. Cambridge University Press.
8. Shmueli, G., Patel, N. Bruce, P. (2010). Data Mining for Business Intelligence: Concepts, Techniques, and Applications in Microsoft Office Excel with XL Miner, Wiley.
9. Silge J. and Robinson D. (2017), Text Mining with R - A Tidy Approach, OReilly Publication

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Practical-IV								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSE-2	MS-ST118P	00	02	02	60	15	35	50

List of Practical: Based on Exploratory Multivariate Data Analysis

Sr. No.	**Title of the Practical**	No. of Practical's
1	Exploratory Multivariate Data Analysis. (Sample mean, variance and covariance matrix, Correlation Matrix.)	2
2	Principal component Analysis (covariance & Correlation technique and them interpretation)	1
3	Factor analysis (PCA, MLE, all Rotations and their interpretation)	2
4	Cluster analysis (Single, Complete, Average, Wards, centroid, k- mean linkage method)	2
5	Canonical correlation.	1
	Total	8

List of Practical: Based on Data Mining

Sr. No.	**Title of the Practical**	No. of Practical's
1	Supervised and unsupervised Understand learning method	2
2	Practical based on feature selection and feature Understand and extraction	1
3	Practical based on Regression Trees, Understand and Random Forests, Bagging and boosting	2
4	Practical based on SVM, Neural Network	1
5	Practical based on clustering algorithms	1
6	Practical based on Text Mining	1
	Total	8

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Research Methedology								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
RM-1	MS-ST119T/P	02	02	04	90	30	70	100

Learning Objectives:

1. To learn critical and creative thinking of model and its components of research.
2. To identifiy the over all process of designing a reserch study from its inception studies.
3. To gain a conceptual overview of Research and the relevant concepts to Research.
4. To learn the different types of Research Designs, Data Collection Tools and Procedures.
5. To know the primary characterstics of quantitative and qualitative resrach.
6. To indentfy the resrach problem stated in a research study.
7. To know the various types of sampling techniques and which one present the most rigorous approach to use.

Course Outcomes (Cos):

1. Students will able to frame good questionnaire and test its reliability and validity.
2. Students will learn different techniques of selecting the random samples.
3. Students will apply statistical tools in design, reseach and development.
4. After completion of this course students will able to apply different sampling techniques to handle different real life problems.

Detailed Syllabus:

Unit I	**Role of Sample Survey in Research Methodology**	**9**
	Introduction of Research: Meaning, Objectives, Scope, Utility. Ethics in research, Types of Research, The Institutional Review Board (IRB),Modern Research and Post-Modern Research Perspectives, Quantitative and Qualitative Research. Objectives of Sample Survey, Methods to conduct Survey: In-person and telephone interviews, mailed and online questionnaires, Longitudinal survey method, cross sectional survey method, designing a questionnaire, characteristics of a good questionnaire, steps in implementing survey methods, scaling methods involve in survey, merits and demerits of sample survey, practical problems in planning and execution of sample survey.	
	Reliability and validity testing of Questionnarie: Test- Retest reliability for the stability, split half test, Kuder Rechardson Coefficient (KR-20), Cronbach's Coefficient Alpha.	
Unit II	**Types of Errors in Sampling**	6

	Types of errors in sampling: Sampling and non–sampling errors, Response errors, mathematical model for Response errors, Hansen Hurwitz technique, Randomized Response Technique (RRT). Warner's randomized response technique.	
Unit III	**Cluster Sampling**	10
	Cluster sampling with clusters of equal sizes, estimation of population mean and its standard error, Relative efficiency of cluster sampling w.r.t. SRSWOR, Effect of cluster size on relative efficiency, unbiased estimator of relative efficiency, cluster sampling as a one way ANOVA, Optimum value of the cluster size, cluster sampling for the proportion.	
	Cluster sampling with cluster of unequal sizes, bias estimator of population mean , bias in the estimator and its MSE, unbiased estimator and relative efficiency of unequal cluster sampling	
Unit IV	**Skills for Paper Writing**	6
	Interpretation of Data and Paper Writing– Layout of a Research Paper, Journals in Science, Impact factor of Journals, Indexing of Journal, When and where to publish ? Ethical issues related to publishing, Plagiarism and Self-Plagiarism (10%), Software for detection of Plagiarism, Use of Encyclopedias, Research Guides, Handbook etc., Academic Databases . Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office.	

List of Practical:

Sr. No.	**Title of the Practical**	No. of Practical's
1	Preperation of Questionnarie on Given Topic	2
2	Testing Reliability of the Questionnarie	1
3	Testing Validity of the Questionnarie	1
4	Cluster sampling with equal cluster size	1
5	Cluster sampling with unequal cluster size	1
6	Two stage sampling with equal and unequal two stage units.	2
7	Survay Sampling	3
	Total	**11**

Suggested Readings/Material:

1. Cochran, W.G: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
2. Sukhatme, P.V., Sukhatme, B.V. and Ashok A.: Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.
3. Murthy, M.N: Sampling Methods, Indian Statistical Institute, Kolkata.
4. Daroga Singh and Choudhary F.S.; Theory and Analysis of Sample Survey Designs, Wiley EasternLtd., New Delhi.

5. Mukhopadhay, Parimal: Theory and Methods of Survey Sampling, Prentice Hall
6. R.S. Rao, Chapman: Sampling methodologies and applications and Hall/CRC 2000
7. Elements of sampling theory and methods: Z. Govindrajalu,Prentice Hall, 1999
8. Adam, K.A., & Lawrence, E.K. (2014). Research methods, Statistics and applications. Singapore: SAGE Publishing.
9. Gaulteney, J.F., & Peach, H.D.(2016). How to do research: 15 labs for the Social & Behavioral Science. Singapore: SAGE Publishing.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Statistical Inference								
Year: I				**Semester: II**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-7	MS-ST121T	03	00	03	45	30	70	100

Learning Objectives:

1. To learn computational skills to implement various statistical inferential approaches.
2. To develop generalization aspect of inferential theory.
3. To get familiarize with the theories and methods of asymptotic inference.

Course Outcomes (Cos):

After completion of this course

1. Students will gain the knowledge of extracting inference scientifically from sample data.
2. Students will have ability to justify the proper inference procedure.
3. Students will learn the long term properties of statistical inference concepts.
4. Students will be competent to attempt national level competitive examination related to Mathematical Sciences and Mental Moral Sciences

Detailed Syllabus:

Unit-I	**Completeness and Sufficiecy**	15
	Fisher information and information matrix, likelihood equivalence, minimal sufficiency, construction of minimal sufficient statistics. Special classes of distributions: multiparameter exponential family, Pitman family, minimal sufficient statistic for special classes of distributions.	
	Completeness, complete sufficient statistics, special classes of distributions admitting complete sufficient statistics, ancillary statistic, Basu's theorem and its applications, estimable functions, estimability of parametric function	
	Cramer-Rao inequality, minimum variance unbiased estimators (MVUE), necessary and sufficient conditions for existence of MVUE, Minimum variance bound unbiased estimators (MVBUE), Chapman-Robin Bounds, Bhattacharya Bounds, Rao-Blackwell theorem, Lehman- Scheffe theorem.	
Unit-II	**Consistency**	10
	Consistency: Definition of consistency, joint and marginal consistency, Invariance property of consistent estimator,	

	Methods of obtaining consistent estimators: method of moments, method of percentiles, choosing between consistent estimator by using mean squared error criterion.	
	Asymptotic relative efficiency, Comparison of consistent estimators, minimum sample size required by the estimator to attain certain level of accuracy.	
Unit III	**CAN Estimator**	10
	Consistent Asymptotic Normal (CAN) estimator for single parameter: Asymptotic Normality, Consistent Asymptotic Normal (CAN) estimators in case of single parameter case, invariance property of CAN estimator under non vanishing differentiable transformation.	
	Delta method, Methods of obtaining CAN estimators: method of moments and method of percentiles, CAN estimator in case of one parameter exponential family.	
Unit-IV	**CAN Estimator in Multiparameter Setup**	10
	CAN estimator in case of multiparameter case: method of moments and percentiles to obtain CAN estimator, CAN estimator in case of multiparameter exponential family. MLE in case of exponential family, for one parameter exponential family MLE of parameter θ is CAN for parameter θ.	
	Cramer regularity conditions, Cramer-Huzurbazar theorem, Extension to vector-valued parameters, Super-efficient estimators, BAN estimators, CAN and BAN estimation for multi-parameter exponential family and applications.	

Suggested Readings/Material:

1. Deshmukh S.R. and Kulkarni M.G.(2021). Asymptotic Statistical Inference: A Basic Course Using R. Springer
2. Casella, G. and Berger, R. L. (2002). Statistical Inference. Duxbury AdvancedSeries, Second Edition.
3. Efron, B. and Hastie, T. (2016). Computer Age Statistical Inference: Algorithms, Evidence and Data Science. Cambridge University Press
4. Kale, B.K. & Muralidharan, K. (2015) Parametric Inference: An Introduction,Alpha Science International Ltd.
5. Lehmann, E.L. and Casella, G. (1998). Theory of Point Estimation. Springer, NewYork
6. Lehmann, E. L. and Romano, J. (2005). Testing Statistical Hypotheses, Springer
7. Rao, C. R. (1995). Linear Statistical Inference and its Applications, Wiley
8. Rohatgi, V. K. and Saleh, A.K. Md. E. (2001). Introduction to Probability and Statistics, John Wiley & Sons, New York.
9. Shao, J. (2003). Mathematical Statistics, Springer-Verlag, New, New York
10. Gupta Anirban Das (2008), Asymptotic Theory of Statistics and Probability, Springer, New York.
11. Manoj Kumar Srivastava, Abdul Hamid Khan and Namita Srivastava (2014), Statistical Inference: Theory of Estimation, PHI Learning Pvt Ltd, Delhi.
12. Ferguson, T.S. (1996), A course on Large Sample Theory. Chapman and Hall, London.
13. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley, New York.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Regression Analysis								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-8	MS-ST122T	03	00	03	45	30	70	100

Learning Objectives:

1. To develop a deeper understanding of the linear and non-linear regression model and its limitations.
2. To develop proper regression models for different data and apply it for future estimation.
3. To study different criteria for model adequacy.
4. To learn the applications of Logistic regression model.

Course Outcomes (Cos):

1. Student able to analyze the regression model with hypothesis tests and interprets the results.
2. Student will apply regression analysis confidently in real life examples.
3. Students will handle the any Big Data and interpret it.

Detailed Syllabus:

Unit-I	**Simple and Multipe Linear Regression**	15
	Simple linear regression, assumptions, inference, diagnostic checks and testing, transformations, method of weighted least squares.	
	Multiple linear regression: Standard Gauss-Markov (GM): 1) Standard Gauss-Markov (GM) setup. 2) GM theorem (statement and proof for Var(ε) = $\sigma^2 I$. Estimation of the Model Parameters: Least square (LS) estimation with and without restrictions on parameters, variance and covariance of LS estimator, estimation of error variance (with and without correlated observations), inadequacy of scatter diagram, maximum likelihood estimation. Hypothesis Testing : 1) Test of Significance of regression. 2) Testing of hypothesis for one and more than one linear parametric functions, 3) Testing of hypotheses about parallelism (slopes)	

	Confidence Interval: Confidence intervals in Multiple Regression, Confidence Interval of the mean response, Simultaneous confidence interval on regression coefficient, Equality of intercepts, Congruence of two simple regression models. Variable selection problems: different methods of variable selection such as forward, backward, best subset etc., multicollinearity and ridge regression, penalized methods, least absolute selection and shrinkage operator, Lack of fit test.	
Unit-II	**Polynomial regression and Diagnostic checks**	10
	Polynomial regression : Polynomial model in One Variable , Polynomial model in two or More Variable Orthogonal polynomial regressions 2.4 Cubic spline regression model	
	Diagnostic checks and correction: Graphical techniques , Tests for normality (Shapiro test, Anderson- Darling test), uncorrelatedness, homoscedasticity , estimation of parameters in autocorrelation.	
Unit III	**Model Adequacy and Treatment to Outliers**	8
	Criteria for model adequacy : Coefficient of Determination R^2, Adjusted R^2, Mallow's Cp, Durbin Watson test.	
	Detection and Treatment of Outliers : Diagnostics for Leverage & Influence, Importance of Detecting Influential Observation, Leverage points, Influential points, Measures of Influence: Cook's D statistic, PRESS statistic. Multicollinearity: Consequences, Tools for detection and remedies, Ridge Regression	
Unit-IV	**Non-linear regression and Logistic regression**	12
	Non-linear regression: Linearization transforms, their uses and limitations, Box and Cox transformations. Generalized linear model: Introduction to link functions such as binomial inverse binomial,inverse Gaussian and Gamma.	
	Logistic regression: Logit transform, ML estimation , tests of hypothesis, Wald test , LR test , Score test , Test for overall regression. Poisson regression: Log link transform, ML estimation , tests of hypothesis , Wald test , LR test, score test, test for overall regression.	

Suggested Readings/Material:

1. Cameron, A. C. and P. K. Trivedi. Regression Analysis of Count Data, Cambridge.
2. Draper, N. R. and Smith, H. Applied Regression Analysis, John Wiley, Third Edition.
3. Hosmer, D. W. and Lemeshow, S. Applied Logistic Regression, Wiley.
4. Kleinbaum, D. G. & Klein, M. Logistic Regression: A Self-Learning Text, Springer.
5. McCullagh, P. and Nelder, J. A. Generalized Linear Models, Chapman& Hall.
6. Montgomery, D. C., Peck, E. A. and Vining, G. G. Introduction to Linear

Regression Analysis, Wiley.
7. Neter, J., W., and Kutner, M. H. Applied Linear Statistical Models,Wiley.
8. Ratkowsky, D. A. Nonlinear Regression Modelling, Marcel Dekker,London.
9. Ruppert, D., Wand, M. P. and Carroll, R. J. Semiparametric Regression,Cambridge University Press.
10. Weisberg, S. Applied Liner Regression, Wiley.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Probability Theory								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-9	MS-ST123T	02	00	02	30	15	35	50

Learning Objectives:

1. To understand the uncertain occurrence situations with logical manner.
2. To get knowledge about various properties of random variable.
3. To learn different modes of convergence.
4. To understand the concept of laws of large numbers and its applications.

Course Outcomes (Cos):

After completing this course

1. Students will be able to address real life problems involving uncertainty using probability.
2. Students will be able to convert real life problems in statistical model.
3. Students will have ability to understand the long term behavior of real life problems.
4. Students can give valid and practically viable interpretations, recommendations, suggestions using statistical base.

Detailed Syllabus:

Unit-I	**Basics of Probability Space**	9
	Review of Algebra of Sets, Partition, Sequence of Set, Limit Superior, Limit Inferior, Limit supremum (Limsup), Limit infimum (Liminf) and Limit of Sequences of Sets, Closer with Respect to Complementation and Intersection (both finite and infinite), Field and Sigma-Field, Minimal Sigma Field, Borel Set and Borel Sigma Field, Class of Events.	
	Point Function and Set Function, Inverse function, Measurable Function, Borel Function, Induced Sigma Field, Function of Function, Economical Definition of Random Variable, Real and Vector Valued Random Variable, Sigma Field induced by a sequence of Random Variable, Limits of Random Variables, Tail events and Tail Measurable Functions, Constructive Definition of Random Variable	
Unit-II	**Probability Measure and Expectation**	6

	Measurable Space, Probability Measure on Measurable Space, Probability Space, Discrete probability Space, Countable Probability Space, Properties of Probability Measure: General Probability Space, Continuity, Extension of Probability Space- Caratheodory Extension Theorem, Induce Probability Space, Distribution of Borel Functions of Random variable, Mixture of Probability Measure. General Probability Measure, Conditional Probability Measure, Counting Measure, Signed Measure, Lebesgue and Lebesgue-Stieltjes Measure.	
	Expectation of Random Variables (All Types), Properties of Expectations, Moment and Different Inequalities of Moments	
Unit-III	**Convergence of Random Variable**	10
	Set of Mutual Convergence, Convergence of A Sequence of Random Variable, Convergence In Probability, Criterion for Convergence in Probability, Convergence in r^{th} Mean, Almost Sure Convergence, Convergence In Distribution (Convergence in Law), Their Interrelations, Cramer's Theorem (Slutsky's Theorem), Closure Properties For Different Type of Convergence, Completeness of Space of all Random Variables.	
	Monotone Convergence Theorem, Dominated Convergence Theorem, Fatou's Lemma, Convergence of Integrable of Measurable functions, Product Space, Product Measure Space, Fubini Theorem (Statement only).	
Unit-IV	**Independence and Law of Large Number**	5
	Independence Of Two Events, Class Of Independent Events, Independence Of Classes, Independence Of Random Variable, Extension of independent Classes, Multiplication Properties, Expectation of the Product of Independent Random Variables, Equivalent Definition Of Independence, Kolmogorov 0-1 Law, Borel Zero-One Criteria, Borel-Cantelli Lemma, Π-System And Λ-System Of Events, Dynkin's Theorem Independence Of Random Variables.	
	Stability of Independent Random Variables: Stability-Weak Law of Large Numbers, WLLN-IID Case, WLLN-Non-IID Case, A.S. Stability, Strong Law of Large Numbers.	

Suggested Readings/Material:

1. Bhat, B. R. (2007). Modern Probability Theory: An Introductory Text Book, New Age International
2. Billingsley, P. (1995). Probability and Measure, 3rdEdition, John Wiley, New York
3. Chung, K. L. (2001). A Course in Probability Theory, Third Edition, Academic Press, London
4. Gut, Allan (2005), Probability: A Graduate Course. Springer, New

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Practical-V (Based on Statistical Process and Product Control)								
Year: I					**Semester: I**			
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-10	MS-ST124P	00	02	02	60	15	35	50

Learning Objectives:

1. To leran diffetnt source of variations in the production process.
2. To leran Control chart as one of the 7-PC tool.
3. To learn online and offline tool to control the quality of the product.
4. To study capability analysis of the process.

Course Outcomes (Cos):

1. On completion of this course students will get thorough knowledge about online and offline techniques to improve quality of the process/ product.
2. Students will get sound knowledge about applications of Statistical Quality Control in the various sectors.
3. Students will able to apply appropriate tools to improve the quality of the product

List of Practical:

Sr. No.	**Title of the Practical**	No. of Practical's
1	Construction of individual control chart, $\bar{X}$ chart and R chart when statandard of the process are given.	1
2	Construction of $\bar{X}$ chart and R chart when statandard of the process are not given.	1
3	Computation of Probability of Catching shift in the Process	1
4	Control Charts for Attribututes when standard of the process given	1
5	Control Charts for Attribututes when standard of the process not given	1
6	Single Sampling Plan	2
7	Determination of Singel sampling plan	1
8	Double sampling plan.	1
9	Process Capability Analysis	2
	Total	**11**

Suggested Readings/Material:

1. Besterfield, D.H. and Michna , C.B. et al. (2009). Total Quality Management, 3rd edition, Pearson Education, Delhi.34
2. Dodge, H.F. and Roming, H.G. Sampling Inspection tables, John Wiley and Sons, Inc. New York
3. Duncan A.J. (1974). Quality Control and Industrial Statistics, fourth edition D.B. Taraporewala
4. Sons and Co. Pvt. Ltd., Mumbai.
5. Grant, E. L. and Leavenworth (1980). Statistical Quality Control, fifth edition, Mc-Graw Hill, New Delhi.
6. Johnson, N.L. and Kotz, S. (1993). Capability Studies, Chapman and Hall Publishers.
7. Kamji and Asher (1996). 100 Methods of TQM, Sage Publishers, Delhi
8. Montgomery, D. C. (2008). Statistical Quality Control, 6thEdn., John Wiley, New York.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Practical-VI (Based on MS-ST122T)								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-11	MS-ST125P	00	02	02	60	15	35	50

List of Practical:

Sr. No.	**Title of the Practical**	No. of Practical's
1	Simple and Multiple Regression and Regression using R.	2
2	Selection of variables in Multiple regression and lack of fit using R.	1
3	Transformation and weighting to correct model inadequacies using R.	1
4	Polynomial regression model (one and two regressors) using R.	1
5	Spline Regression using R.	1
6	Logistic Regression using R.	1
7	Poisson Regression using R.	1
8	Model adequacy checking using R.	1
	Total	**9**

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Practical-VII (Based on Numercial Analysis)								
Year: I				**Semester: I**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSC-12	MS-ST126P	00	02	02	60	15	35	50

Learning Objectives:

1. To learn diffreent method of solving linear homoegoneous Equations
2. To learn fitting equation of straight and non-linear equations.
3. To study different techniques of solving numerical integration.

Course Outcomes (Cos):

1. Understanding the theoretical and practical aspects of the use of numerical methods.
2. Implementing numerical methods for a variety of multidisciplinary applications.
3. Establishing the limitations, advantages, and disadvantages of numerical methods.

List of Practicals:

Sr. No.	**Title of the Practical**	No. of Practical's
1	Solution of Equations by using Bisection method, The method of False position,	2
2	Solution of Equations by using Newton- Raphson metho and Gauss Seidal Method	2
3	Fitting of straight line and second degree curve using Least Square Method.	2
4	Fitting of Power function and Exponential function using Least Square Method.	2
5	Newton's forward and Backward Interplation	1
6	Lagrangian Interplation and Interpolation using Newton's divided difference formula	2
7	Numerical Integration using Trapezoidal rule and Simphson's rule.	2
8	Solution of first order differential equation	1
	Total	**14**

Suggested Readings/Material:

1. H.C. Saxena, Finite differences and Numerical Analysis, S. Chand and Company.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India, 1999.
3. K.E. Atkinson, An Introduction to Numerical Analysis, Wiley Publication.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Inferential Multivariate Analysis								
Year: I				**Semester: II**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSE-3	MS-ST127T	02	00	02	30	15	35	50

Learning Objectives:

1. To study the Multivaiate normal distribution and its real life application.
2. To estimate the parameter involves in the multivariate normal distribution.
3. To study the Wishart distribution and its real life application.
4. To learn Hotelling's T^2 and Mahlnobies D^2 Statistic.
5. To discuss applications of Hotelling's T^2 and Mahlnobies D^2 Statistic in real life.

Course Outcomes (Cos)

1. The aim of this course is to build confidence in the students in analyzing and interpreting multivariate data.
2. Students will get idea to visualize multivariate data.
3. Providing guidelines to identify and describe real life problems so that relevant data can be collected.
4. Students will develop the procedure for estimating parameters of a model developed,
5. Students will handle big data and their interpretation by using suitable software.
6. Interpreting model results in real life problem solving, and Providing procedures for model validation.

Detailed Syllabus:

Unit-I	**Multivariate Normal distribution and its Inference**	10
	Multivariate Normal distribution: Multivariate Normal distribution and its properties, marginal, conditional and partitioned multivariate normal Distribution, moment**s,** MGF, characteristic function, distribution of linear combination of Multivariate normal distribution. Singular and nonsingular multivariate distribution, sampling from multivariate normal distribution and maximum likelihood estimation- multivariate normal likelihood, MLE of mean vector and dispersion matrix, unbiasedness and sufficiency, MLES of parametric of multivariate normal distribution,Multivariate normal probability plot. Sampling distribution of sample mean vector and sample variance-covariance matrix, Tests and confidence region for the mean when dispersion matrix is known.	
Unit-II	**Wishart Distribution**	5

	Wishart Distribution: Wishart distribution and its properties, Null and non-null distribution of sample correlation coefficient, Concept of partial and multiple correlation coefficient, Null distribution of partial and multiple correlation coefficient. Detecting outliers and cleaning data. Transformation to near normality.	
Unit-III	**Hotelling's T^2**	9
	Hotelling's T^2: Hotelling's T^2 statistic and its Null distribution, its Application, tests on mean vector for one ($\underline{\mu} = \underline{\mu}\,0$) and two ($\underline{\mu}\,1 = \underline{\mu}2$) multivariate normal populations, test for equality of the components of a mean vector in a multivariate normal population. confidence region for mean vector of multivariate normal distributions, Mahlnobies D^2 Statistic and its applications.	
Unit-IV	**Discriminant Analysis**	6
	Likelihood ratio test, Classification and discrimination procedures for discrimination between two multivariate normal populations-sample discriminant function, test associated with discriminant functions, probabilities of misclassification and their estimation..	

Suggested Readings:

1. Anderson T.W. (1983): An Introduction to Multivariate Statistical Analysis (Second Edition) Wiley.
2. Johnson, R. and Wychern (1992): Applied Multivariate Statistical Analysis, prentice- Hall, 3rd. Ed
3. Giri, N.C. (1977): Multivariate Statistical Inference. Academic Press.
4. Khsirsagar A.M. (1972): Multivariate Analysis. Marcel Dekker.
5. Morrison, D.F. (1976): Multivariate Statistical Methods. 2nd. Ed. McGRAW Hill.
6. Muirhead, R.J. (1982) Aspects of Multivariate Statistical Theory, J.Willey.
7. Seber, G.A.F. (1984): Multivariate Observations. Wiley
8. Sharma, S. (1996): Applied Multivariate Techniques. Wiley.
9. Srivastava M.S. & Khatri C.G. (1979): An Introduction to Multivariate Statistics. North Holland.
10. R coding book, SPSS book for multivariate book

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Categorical Data Analysis								
Year: I				**Semester: II**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSE-3	MS-ST127T	02	00	02	30	15	35	50

Learning Objectives:

1. To learn different statistical tools to handle categorical data.
2. To study thetheorrtoical concept in analysis of categorical data.
3. To learn different models for categorical data such as Generalized Linear, logit, logistic, log linear and matched pair test.

Course Outcomes (Cos):

1. On successful completion of the course, the student must be able to use basic concepts and common statistical models to analyses for categorical data.
2. The student who successfully completes this course should have a reasonable grasp of the theoretical foundations of categorical data analysis
3. The end of this course, students should be able analyse use categorical data analysis methods to analyse real data using current statistical software, write about, critique applications of and read methodological articles about categorical data analysis
4. This course is designed to introduce; to provide enough theory, examples of applications in a variety of disciplines (especially in social and behavioural science)

Detailed Syllabus:

Unit-I	**Introduction**	9
	Introduction to Categorical Data analysis: Categorical response data: Probability distributions for categorical data: Binomial distribution, Multinomial distribution. Statistical inference for discrete data: Likelihood function and MLE, significance test for binomial distribution, Confidence interval for Binomial distribution, Wald's Likelihood ratio and score inference for Binomial distribution.	
	Contingency tables: Probability structure for contingency tables: Joint, Marginal and conditional distribution, sensitivity and specificity and independence. Comparing proportions with 2x2 tables: Difference of proportion, Relative risk.	
	The odds ratio : Properties of odd ratio, inference for odd ratios and log odd ratios, relationship between odd ratios and relative risk with real life example	

Unit-II	**Test for independence, GLM and Statistical Inference**	9
	Tests for independence: Person statistic and chi squared distribution, Likelihood ratio Statistics, Test of independence, partitioning chi- squared, linear trend alternative to independence for ordinal data, choice of score. Trend test for L X 2 and 2 X J tables. Nominal and ordinal tables. Exact inference for small sample: Fisher's exact test for 2X2 table, small sample Confidence Interval for Odd Ratio Extension to three-way and larger tables: Partial Tables, Conditional Versus Marginal association, Simpson's Paradox, Conditional and marginal Odd ratios, Conditional Independence versus Marginal Independence, Homogenous association.	
	Statistical inference: Statistical inference and model checking: Inference about model Parameters, the Deviance, Model comparison using the Deviance Fitting GLMs: Wald's, Likelihood-Ratio and Score inference use the likelihood function, Advantages of GLM.	
Unit-III	Logistic and Multiple logistic regression	6
	Multiple logistic regression: Logistic regression with categorical predictors: Indicator variables Represent Categories of Predictors, ANOVA type model representation of factors, The Cochran – Mental-Haenszel Test 2 X 2 X K Contingency tables, Testing the homogeneity of odd ratio Multiple logistic regression : Model Comparison to check whether a term needed, Quantitative treatment of Ordinal Predictor, Allowing interaction	
	Summarizing effects: Probability based interpretation, Standardized interpretation Building and applying logistic regression models: Strategies in model selection, Step wise variable selection algorithms, AIC, ROC Model Checking: Likelihood- Ratio Model Comparison Test, Goodness of fit and the Deviance	
Unit-IV	**Multi category logit, Log-linear models**	6
	Multi category logit models: Logit Models for nominal responses: Base line-Category logits, Estimating response probabilities, Discrete choice models. Cumulative logit model for ordinal responses- Cumulative logit models with proportional property, inference about model parameter, checking model fit, interpretations comparing cumulative probabilities. Latent variable Motivation, Invariance to choice of response categories	
	Log-linear models for contingency tables: Log-linear models for two-way and three-way tables: Log-linear model of independence for three- way tables. Interpretation of parameters in independence model. Inference for Log-linear models: Log linear cell residuals, Tests about conditional associations, Log linear model for higher order dimension, Three factor interaction	

Suggested Readings :

1. Agresti, Alan (2002). Categorical Data Analysis. Second Edition. New York: John Wiley and Sons.
2. Stokes ME, Davis CS, Koch GG. (2000). Categorical data analysis using the SAS system. Cary, NC: SAS Institute, INC.

3. Agresti, Alan (2007). An Introduction to Categorical Data Analysis. Second Edition. New York: John Wiley and Sons. ISBN: 978-0-471- 22618-5
4. Cameron, A. Colin and Pravin K. Trivedi. 1998. Regression Analysis of Count Data. Oxford: Oxford University Press.
5. Christensen, Ronald. 1997. Log-linear Models and Logistic Regression (2nd ed.). New York: Springer.
6. Greene, William C. 2000. Econometric Analysis (4th ed.). New York: Prentice Hall.
7. Hosmer, David W. and Stanley Lemeshow. 2000. Applied Logistic Regression. 2nd Edition. New York: Wiley.
8. King, Gary. 1989. Unifying Political Methodology: The Likelihood Theory of Statistical Inference. Cambridge: Cambridge University Press.
9. Powers, Daniel A. and Yu Xie. 2000. Statistical Methods for Categorical Data Analysis. San Diego: Academic Press.

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar
(Autonomous)
Syllabus
M.Sc. Statistics

Title of the Course: Practical –VIII (Based on MS-ST127T)								
Year: I				**Semester: II**				
Course Type	Course Code	Credit Distribution		Credits	Allotted Hours	Allotted Marks		
		Theory	Practical			CIE	ESE	Total
DSE-4	MS-ST128P	00	02	02	60	15	35	50

List of Practical: Inferential Multivariate Analysis

Sr. No.	**Title of the Practical**	No. of Practical's
1	Model Sampling from Multivariate Distribution and computation of MLE's of Parameters.	1
2	Marginal, Conditional distribution of random sample from multivariate normal distribution (Q-Q , contour plot , Normal plot)	1
3	Applictions of Wishart distribution	1
4	Applications of Hotelling T2 Statistic	2
5	Discriminant Analysis (Fishers linear discriminant function)	1
6	Likelihood ratio test	1
7	Multivariate Analaysis of Variance (MANOVA)	2
	Total	**9**

List of Practicals: Categorical Data Analysis

Sr. No.	**Title of the Practical**	No. of Practical's
1	Contingency tables (Joint, Marginal and conditional distribution, sensitivity and specificity and independence. Comparing proportions with 2x2 tables: Difference of proportion, Relative risk.)	1
2	Exact inference for small sample	1
3	Fitting GLMs and multiple logistic regression.	1
4	Logistic regression for matched pairs.	2
5	Log linear models for two way and three way tables.	1
6	The Cochran – Mental-Haenszel Test, 2 X 2 X K Contingency tables.	1
7	McNemar Test	2
	Total	**9**