Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati
Autonomous

Course Structure for M.Sc. Statistics (2022 Pattern)
(w. e. from June, 2022)

Name of the Programme : M.Sc. Statistics

Program Code : PSST

Class : M.Sc. Part – I

Semester : I

Paper Code	Title of Paper	No. of Credits
PSST111	Mathematical Analysis	4
PSST112	Linear Algebra	4
PSST113	Probability Distributions	4
PSST114	Sampling Theory	4
PSST115	Statistics Practical – I	4
PSST116	Statistics Practical – II	4

Name of the Programme : M.Sc. Statistics

Program Code : PSST

Class : M.Sc. Part – I

Semester : II

Paper Code	Title of Paper	No. of Credits
PSST121	Probability Theory	4
PSST122	Parametric Inference	4
PSST123	Multivariate Analysis	4
PSST124	Regression Analysis	4
PSST125	Statistics Practical – III	4
PSST126	Statistics Practical – IV	4

SYLLABUS (CBCS) FOR M.Sc. Statistics
(w. e. from June, 2022)

Name of the Programme	**:** M.Sc. Statistics
Program Code	**:** PSST
Class	**:** M.Sc. Part – I
Semester	**:** I
Course Name	**:** Mathematical Analysis
Course Code	**:** PSST111
No. of lectures	**:** 60
Credit	**:** 4 credits

Course Outcomes:

The students will acquire knowledge about the;

1 basic topological concepts like countable set, uncountable set, open set, closed set and compact set.
2 concept of convergence of sequence of real numbers, pointwise and uniform convergence of sequence of functions.
3 concept of convergence of series of real number and able to calculate radius of convergence of power series
4 fundamental ideas and applications of calculus.
5 concepts required for further studies in Probability Theory and Asymptotic Inference.

TOPICS/CONTENTS:

Unit 1:

Set of real numbers, supremum and infimum of sets of real numbers, real field, Euclidean spaces, Finite, Countable and uncountable sets, metric spaces, interior points and limit points of a set, open set, closed set and Compact set. Bolzano-Weierstrass theorem and Heine-Borel theorem (statement only). Application of these theorems. **(15L)**

Unit 2:

Sequence of real numbers, convergence and divergence of sequence, subsequences of a sequence, Cauchy sequences, completeness of R, limit inferior, limit superior of the sequences, some special sequences. **(15L)**

Unit 3:

Series of real numbers, convergence of series, tests for convergence of series (ratio test, root test) (without proof), alternative series, conditional and absolute convergence, power series and radius of convergence, examples and problems on these concepts. **(15L)**

Unit 4:

Limits of functions, continuous function, discontinuity, uniform continuity, continuity and compactness, monotone function and discontinuity. Introduction and examples of sequence of real valued function, pointwise convergence of sequence of functions, definition of uniform convergence of sequence of function. Riemann integral, refinement of partitions, condition of integrability, Riemann sums, fundamental theorem of calculus, definition and existence of Riemann-Stieltjes integral, a condition of integrability **(15L)**

References:

1. Ajit Kumar (2019), A Basic Course in Real Analysis, A Chapman & Hall Book.
2. Apostol T.M. (1975). Mathematical Analysis: A modern approach to advanced calculus. Addison-Wesley
3. Bartle R. G. (1976). Elements of Real Analysis, John Wiley
4. Bartle R.G. & Sherbert D.R. (2000): Introduction to Real Analysis-John Wiley & Sons Inc.
5. Ghorpade, S. R. and Limaye, B. V. (2006). A Course in Calculus and Real Analysis, Springer
6. Goldberg R.R.(1964): Methods of Real Analysis-Blaisell Publishing company, New York, U.S.A.
7. Kumar A. and Kumaresan S. (2014), A basic course in real analysis, CRC Press.
8. Mapa S. K. (2018) Inroduction to Real Analysis, Sarat Book Distributors, Kolkata
9. Rudin, W. (1985). Principles of Mathematical Analysis, McGraw-Hill

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Name of the Programme	**:** M.Sc. Statistics
Program Code	**:** PSST
Class	**:** M.Sc. Part – I
Semester	**:** I
Course Name	**:** Linear Algebra
Course Code	**:** PSST112
No. of lectures	**:** 60
Credit	**:** 4 credits

Course Outcomes:

The students will acquire knowledge about the;

1 basic concepts of vector and matrix algebra
2 real vector spaces and subspaces and apply their properties.
3 concepts of base and dimension of vector space.
4 concept of dimension of a vector space.
5 concepts of linear systems, independence, theory of matrices, linear transformations, bases and dimension, eigenvalues, eigenvectors and diagonalization.

TOPICS/CONTENTS:

Unit 1:

Vector space, subspace, linear dependence and independence, basis and dimension of a vector space, orthogonal and orthonormal vectors, null space, Gram-Schmidt Orthogonalization process, orthonormal basis, orthogonal projection of vector, algebra of matrices, row and column spaces of a matrix, elementary operations. **(15 L)**

Unit 2:

Partitioned matrix, Elementary matrix, Determinant of a matrix, elementary properties, Determinant and inverse of partitioned matrix, Kronecker product. Rank of a matrix, rank and nullity, inverse of a matrix null space, idempotent matrix, Generalised inverse, Moore-Penrose generalized inverse, solution of a system of homogenous and non-homogeneous linear equation, theorem related to existence of solution and examples **(15 L)**

Unit 3:

Eigen values and eigen vectors, eigen spaces, Geometric and algebraic multiplicity of an eigen value, Properties of eigen values. Right and left characteristic vector, orthogonal property of characteristic vector Cayley-Hamilton theorem and minimal polynomial, application of Caley Hamilton theorem and its applications. Spectral decomposition of real symmetric matrix singular value decomposition, nth power of a matrix, Jordan decomposition.

(15 L)

Unit 4:

Real Quadratic form (QF), Classification, Rank and signature, reduction of any QF to diagonal form. Definiteness of a matrix, equivalence of nonnegative definite matrix and variance covariance matrix, Simultaneous reduction of two QF, simultaneous reduction of two quadratic forms, maxima and minima of ratio of quadratic form. **(15 L)**

References:

1. Graybill, F.A(1961) An Introduction to Linear Statistical Models Vol 1,McGraw-Hill Book Company Inc.
2. Hadely G.(1962) Linear Algebra,Narosa Publishing House.
3. Harville D. (1997) Matrix Algebra From Statistics Perspective,Springer.
4. Kumaresan S. (2000), Linear Algebra: A geometric approach, Prenttice Hall.
5. R. B. Bapat Linear Algebra and Linear Models.
6. Rao A.R. and Bhimasankaram P.(2000),Linear Algebra,Second edition,Hindustan Book Agency.
7. Rao C.R. (2001) Linear Statistical Inference and Its Application,Second Edition,Wiley.
8. Schott J. (2016) Matrix Analysis for Statistics,Third edition Wiley.
9. Searl S.B.(2006) Matrix Algebra Useful for Statistics,Wiley.

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Name of the Programme	**:** M.Sc. Statistics
Program Code	**:** PSST
Class	**:** M.Sc. Part – I
Semester	**:** I
Course Name	**:** Probability Distributions
Course Code	**:** PSST113
No. of lectures	**:** 60
Credit	**:** 4 credits

Course Outcomes:

Students should be able to:

1. understand characteristics about discrete and continuous random variable and their probability distributions.
2. prepare students for modeling real data using distributions
3. develop understanding of distribution theory related for further advanced topics in statistical inference.
4. develop problem-solving techniques to solving real-world events.
5. apply selected probability distributions to solve problems.

TOPICS/CONTENTS:

Unit 1:

Random experiments and it's sample space, probability axioms, random variables, probability distribution of random variables, discrete and continuous random variable, functions of random variables and its distribution, mixture of probability distribution, m.g.f, p.g.f of distribution function. Moment inequalities: Markov, Chebychev, Holder, Minkowski and Jensen's inequalities with their applications. Basic inequality **(15 L)**

Unit 2:

Multiple random variables, joint, marginal and conditional distribution, variance covariance matrix, independence of random variables, marginal and conditional densities using joint densities, conditional expectations and variance, convolution of random variable,

compound distribution, exponential family of distribution, location and scale families, non-regular family. **(15 L)**

Unit 3:

Bivariate normal, bivariate Poisson, bivariate exponential, (Olkins method 3 types), multinomial, Dirichlet, sampling distribution of statistics from univariate normal random samples. **(15 L)**

Unit 4:

Non-central χ^2, t, F distribution and their properties, distribution of linear and quadratic forms in iid standard normal variable (technique based on m.g.f.), Independence of two linear forms, Independence of two quadratic forms and independence of linear and quadratic forms, order statistics, joint distribution of order statistics, distribution of r^{th} order statistics, joint distribution of (r^{th} and s^{th} order statistics and their function), distribution of range. **(15 L)**

References:

1. Anirban DasGupta, Fundamentals of Probability: A First Course
2. Casella and Burger(2002) Statistical Inference (Duxbury advanced series II edition)
3. Feller, Fundamentals of Probability: A First Course
4. Hogg R. V. and Craig R. G. (1978): Introduction to Mathematical Statistics Ed.4.
5. Johnson N.L. & Kotz S.(1996) Distributions in statistics Vol.I .VolI and Vol III John Wiley and sons Inc.)
6. Johnson N.L., Kotz S., Balkrishnan, N. Multivariate Distributions (John Wiley and sons)
7. Rohatagi V.K. & Saleh A.K.(2001) Introduction to probability theory and mathematical statistics. (John Wiley and sons)
8. Rohatgi V. K. and Saleh A. K. Md. E. (2002): An Introduction to probability and statistics, John wiley & Sons (Asia)

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Name of the Programme : M.Sc. Statistics
Program Code : PSST
Class : M.Sc. Part – I
Semester : I
Course Name : Sampling Theory
Course Code : PSST114
No. of lectures : 60
Credit : 4 credits

Course Outcomes:

Students should be able to:

1. define principal concepts about sampling
2. explains the advantages of sampling.
3. lists the stages of sampling process
4. categorizes and defines the sampling methods
5. apply the appropriate sampling method

TOPICS/CONTENTS:

Unit 1:

Objectives of sample survey, planning for sample survey, concept of sampling distribution of statistic, Simple random sampling with replacement, Simple random sampling without replacement, systematic sampling and related results on estimation of population total, mean and proportion, circular systematic sampling, stratified sampling: formation of strata and number of strata, allocation problems and estimation problems, deep stratification and method of collapsed strata. **(15L)**

Unit 2:

Inclusion probabilities, 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, PPSWOR methods and related estimation of a finite population

mean (Horvitz-Thompson and Des Raj estimators for a general sample size and Murthy's estimator for a sample of size 2), Midzuno sampling, Rao-Hartley-Cochran sampling strategy.

(15L)

Unit 3:

Use of supplementary information for estimation: ratio and regression estimators and their properties. Unbiased and almost unbiased ratio type estimators of population mean, post stratification, Cluster sampling cluster sampling with clusters of equal sizes and unequal sizes, Two – stage sampling with equal number of second stage units, multistage-sampling, stratification estimator, multiphase sampling. **(20L)**

Unit 4:

Sampling and non-sampling errors, Response and non response errors, Hansen–Hurwitz and Deming's model for the effect of call-backs, Randomized response technique (RRT), Warner's model, MLE in Warner's model, related and unrelated questionnaire methods. **(10L)**

References:

1. Des Raj & Chandhok P.(1998), Sample survey theory. (Narosa)
2. Murthy M.N.(1977) Sampling theory and methods. (Statistical Publishing Society)
3. Parimal Mukhopadhyay, Theory and methods of survey sampling, Prentice Hall of India private limited, 2nd Edition, 2008.
4. Sukhatme P.V. Sukhatme B.V. and C. Ashok Sampling theory of survey and applications. (Indian society for Agricultural statistics)
5. W.G.Cochran, (1977) Sampling techniques.(John Wiley and sons)

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Name of the Programme : M.Sc. Statistics
Program Code : PSST
Class : M.Sc. Part – I
Semester : I
Course Name : Statistics Practical – I
Course Code : PSST115
No. of lectures : 60
Credit : 4 credits

Course Outcomes:

Students should be able to:

1 review the core topics in probability and statistics through the study and practice of data analysis and graphical interpretation using statistical software.
2 solve systems of linear equations using various methods.
3 plots different probability distributions and draw a model sample from it.
4 construct the orthogonal matrix, diagonalization of a symmetric matrix etc.
5 understand various discrete and continuous probability distributions along with their real-life applications

Sr. No.	Title of Experiments
1.	Introduction to Statistical Software – I (Minitab, R, Matlab, SPSS)
2.	Matrices
3.	G-Inverse and MPG-Inverse
4.	Eigen value, Eigen vectors, Spectral decomposition, Power of matrix- I
5.	Eigen value, Eigen vectors, Spectral decomposition, Power of matrix- II
6.	Solution of system of linear equations using Gauss elimination, Gauss Jordon, Gauss Seidal and Gauss Jacobi methods
7.	Application of Calley- Hamilton Theorem
8.	Classification and reduction of quadratic forms
9.	Plotting of density function, distribution functions, computation of probability of events related to bivariate probability distribution, computation of probability of non-central χ^2, t, F-distributions
10.	Model sampling from Gamma, Chi-square, Weibull, Lognormal probability distribution
11.	Model sampling from discrete, continuous and mixture distribution
12.	Model sampling from bivariate probability distribution

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Name of the Programme : M.Sc. Statistics
Program Code : PSST
Class : M.Sc. Part – I
Semester : I
Course Name : Statistics Practical – II
Course Code : PSST116
No. of lectures : 60
Credit : 4 credits

Course Outcomes:

Students should be able to:

1 use statistical software for the analysis and interpretation of the outcomes.
2 estimate parameters under various sampling techniques.
3 find solutions of equations using various numerical computing methods.
4 understand different sampling survey methods and give examples of situations where these methods are useful.
5 learn R-reporting and developing own R code and use of different R packages.

Sr. No.	Title of Experiments
1.	Estimation of parameters in simple random sampling using SRSWR and SRSWOR
2.	Estimation of parameters in Systematic sampling
3.	PPS sampling
4.	Ratio and Regression estimates
5.	Stratified sampling (using ratio and regression)
6.	Cluster sampling with equal and unequal cluster size
7.	Two stage sampling
8.	Simultaneous Transcendental equations
9.	Bivariate Interpolation
10.	Unconstraint Optimization Techniques
11.	Computation of integral by Riemann and Riemann-Stieltjes integral
12.	Jackknife technique and Bootstrap technique