Syllabus for M.Sc. Statistics Entrance 2022

There will be a total of 60 questions (Mathematics+Statistics) and candidate has to attempt only 30 of these. If the candidate attempt more than 30, only the first 30 will be evaluated. All questions will be carrying 2 marks each.

STATISTICS

DESCRIPTIVE STATISTICS

Types of data-Primary and secondary data, qualitative and quantitative data. Methods of collecting data. Diagrammatic and graphical representation of data-Bar diagram, Histogram, Frequency polygon and ogives.

Measures of central tendency or location (Arithmetic mean, median, mode, geometric mean and harmonic mean). Characteristics of a good average. Relationship between various measures of location and their applications. Merits and demerits of these measures. Dispersion: Relative and absolute measures (Range, Quartile Deviation, Mean Deviation and standard Deviation). Coefficient of variation and its applications.

Skewness, Kurtosis and their measures including those based on quartiles. Moments, relation between central moments in terms of raw moments and vice-versa. Effect of change of scale and origin on moments. Sheppard's correction for grouping errors. Coefficients based on moments (α, β & γ coefficients).

Bivariate Data: Concept of correlation and its types. Scatter diagram method and product moment method of studying correlation. Properties of a correlation coefficient (limits of the Pearson correlation coefficient, effect of change of origin and scale). Concept of rank correlation, derivation of Spearman's rank correlation coefficient and its limits.

Principal of least squares and fitting of first-degree polynomial and parabola. Meaning of regression, derivation of two regression lines. Regression coefficients and their properties.

PROBABILITY THEORY AND PROBABILITY DISTRIBUTIONS

Probability: Random Experiment: Trial, sample space, event, operation of events, independent events, exhaustive events and mutually exclusive events. Classical and relative frequency approach to probability with their merits and demerits. Axiomatic approach to probability. Addition and multiplication law of probability. Conditional probability, independence of events, Prior and posterior or revised probabilities, Bayes' theorem, its applications and importance.

Random Variables: Discrete random variable, probability mass function, continuous random variable, probability density function. Expectation of random variables and their properties. Moment generating functions(mgf), properties and uses.

Standard univariate discrete distributions: Uniform, Binomial, Poisson, Geometric, and Hypergeometric distribution (their applications and properties mean variance and mgf).

Continuous univariate distributions: Uniform, Exponential, Gamma and Normal (their applications and properties, mean, variance and mgf)

LARGE SAMPLE TESTS AND SAMPLING DISTRIBUTIONS

Concept of population, sample, Statistic, parameter and sampling distribution. Standard error of sample mean and sample proportion. Statistical hypothesis and its types. One tail and two tail tests. Types of errors, level of significance and critical region. Procedure for testing of hypothesis.

Large sample tests: Tests of significance for testing of a single mean, single proportion, difference of two means and two proportions.

Tests of significance based on Chi- square. Conditions for applying Chi-square test.Test for goodness of fit. Contingency table (2 X 2) and tests of independence of attributes in a contingency table. Yates' corrections. Chi-square test for specified value of population variance.

Exact sampling distributions: t- Statistics. Test for single mean and difference between two means. Paired t-test for difference between two means. F- Statistics or Variance Ratio Test. Assumptions in F-test. Tests of hypothesis of the variance of two populations.

SAMPLING THEORY

Sampling Theory: Need for sampling, Census and sample survey, basic concept in sampling, Principles of sample survey, advantages of sample survey over census. Sampling and non-Sampling errors.

Simple random sampling (SRS) with and without replacement. Merits and demerits of Simple random sampling (SRS). Methods of selecting SRS. Estimation of mean, its Variance and estimate of its variance. Unbiased estimate of population mean square.

Stratified random sampling: Need for stratification. Principles of stratification. Advantages of stratified sampling over simple random sampling. Estimation of mean and variance. Proportion and Optimum allocation:Allocation of sample size under proportional and optimum allocation and variance under these allocations. Comparison of stratified sampling over SRS.

Systematic sampling: Advantages of systematic sampling over SRS and stratified sampling. Estimation of mean and its variance Comparison of systematic sampling over SRS and stratified sampling.

OPERATIONS RESEARCH

Operations Research (OR): Introduction to Operations Research its Development, characteristics and scope. Importance of Operations Research in industry. Limitations of OR.

Linear programming: Introduction to linear programming (LPP), Concepts of Convex set, basic solution, feasible solution, basic feasible solution, optimum solution and slack & surplus variables in linear programming problems (LPP). Mathematical formulation of LPP, Standard form of LPP, graphical method of solving LPP.

Simplex Method: Iterative nature of simplex method, computational details of simplex algorithm and summary.Artificial variable techniques (Two-phase and Big-M techniques) for solving a general LPP.

Transportation Problem (TP): Mathematical formulation and tabular representation. Concept of feasible, Basic feasible and optimal solutions with reference to T.P. Methods for finding initial basic feasible solution : North-West Corner Rule, Lowest Cost Entry , Vogel's Approximation method.

STATISTICAL INFERENCE AND DEMOGRAPHY

Statistical Inference, parameter, Parameter space, Statistic and its sampling distribution. Types of Estimation (Point and Interval· estimation).Estimate and estimator. Requirements of a good estimator with examples. Unbiasedness, consistency, efficiency and sufficiency. Statement of Neyman-Factorization theorem with examples.
Methods of Estimation: Maximum likelihood Estimation (MLE), method of moments, method of minimum chi-square and method of least square. Examples on MLE and method of moments.

Introduction and definition of vital Statistics, coverage and content errors in demographic data, use of balancing equations, Chanderasekharan-Deming formula to check completeness of registration data. Accuracy of age data on sex and age: Whipple's and Myer's indices. Dependency ratio. Measure of fertility; relationship between CBR, GFR and TFR. Mathematical models on fertility and human reproduction process.
Mortality: concepts and rates; measures of infant mortality rate. Force of mortality. Life table and its construction: Complete and abridged. Greville's and Reed-Merrels methods. Relationship between life table functions and their estimation. Relationship between abridged life table functions. Logistic Model for population growth and their fitting to population data. Migration: concepts and rates. Uses of place of birth and duration of residence data.

MATHEMATICS

CALCULUS AND COMPLEX TRIGNOMETRY

Limit and Continuity ($\in$ and δ definition), types of discontinuities, properties of continuous functions on closed intervals, uniform continuity and Heine's Theorem, Differentiability of functions, Successive differentiation, Leibnitz's theorem, partial differentiation, total differentials, Euler's theorem on homogenous functions.

Integration of rational and irrational functions, definite integrals and their properties, reduction formulae for integrals of rational, trigonometric, exponential and logarithmic functions and of their combinations.

Tangents and normals (polar coordinates only), pedal equations, curvature and radius of curvature, asymptotes, singular points, tracing of curves in cartesian and polar coordinates.

Review of complex number system, triangle inequality, equation of a circle and ellipse in complex form, De Moivere's theorem and its applications, expansion of sin nθ, cos nθ etc. in terms of powers of sin θ, cos θ and expansion of sinn θ and sosn θ in terms of multiples of θ.

Functions of a complex variable, exponential, circular, hyperbolic, inverse hyperbolic and logarithmic functions of a complex variable and their properties, summation of trigonometric series, difference method, C + iS method, C-R equations, definition of analytic functions.

DIFFERENTIAL EQUATIONS AND THEORY OF EQUATIONS

Differential equations, integrating factors, Bernoulli's equation, exact differential equations, necessary and sufficient conditions for exactness, symbolic operators, homogeneous and non-homogeneous linear differential equations with constant and variable coefficeints.

Miscellaneous forms of differential equations, first order higher degree equations solvable for X, Y, Z, P equations from which one variable is explicitly absent, Clairut's form, equations reducible to Clairut's form.

General properties of polynomials, Synthetic division, relation between the roots and the coefficients of an equation, transformation of equations, diminishing of roots of an equation by a given number, removal of terms of an equation, formation of equations whose roots are functions of the roots of a given equation, equation of squired difference.

Symmetric functions, Newton's method for finding the sum of the powers of the roots of an equation, Cardan's solution of the cubic, nature of the roost of a cubic, Descartes solution of a biquadratic, Descartes rule of signs, rational roots of an integral polynomial, location of roots of an equation (simple cases).

REAL ANALYSIS

Finite and infinite sets, countable and uncountable sets, countability of rationals, uncountability of reals, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, Cluster points, Nested interval Theorem, Bolzano-Weierstrass theorem.

Sequences, types of sequences (bounded, unbounded, Cauchy, convergent, divergent, oscillatory sequences), Cauchy convergence criterion of sequences and related results, limit superior and limit inferior, Cauchy's theorem on limits, monotone sequences and their convergence.

Infinite series, convergence and divergence of an infinite series, Cauchy convergence criterion for series, positive term series, geometric series, comparison tests, Root test, Ratio test, Integral test, Raabe's test, Gauss's test, alternating series, Leibnitz's test, absolute and conditional convergence.

Riemann integration, lower and upper sums, refinement of a partition, behaviour of lower and upper sums under refinement, definition and existence of the Reimann integral, necessary and sufficient condition for R-integrability of a bounded function, R-inetgrability of sum, difference, product and quotient of two functions, R-inetgarbilty of continuous, monotone and discontinuous functions (having finite number of discontinuity) in an interval, Mena Value Theorem for integrals.

ABSTRACT ALGEBRA

Groups, Semi-groups and sub-groups, Cyclic groups and their sub-groups, cosets and Lagrange's theorem, product of sub-groups, counting principle for the number of elements in HK, normaliser ad centre.

Normal subgroups and various criteria for normality of a sub-group, Qoutient Groups, Group homomorphism and isomorphism, Examples.

Fundamental theorem of homomorphism, Correspondence theorem, second and third theorems of isomorphism, Permutation Group, Even and odd Permutations, Symmetric group of degree n, alternating group, simple group, Cayley's theorem.

Rings, Division rings and Fields, Sub-rings and Sub-fields, Ideals, Quotient rings, Principal ideals, Prime ideals, Maximal ideals and characterisations in terms of their associated quotient rings, Ring homomorphism and isomorphism, theorems on ring isomorphisms.

LINEAR ALGEBRA

Types and properties of matrices, Inverse of a square matrix, matrix polynomials, characteristic equation, Cayley-Hamilton Theorem , Eigen values and eigen vectors of matrices and their determination, rank of a matrix, invariance of rank matrix under elementary transformations. Reduction of matrix to normal form, elementary matrices.

Linear dependence and linear independence of row (column) vectors, conditions for columns of a matrix to be linearly dependent, matrix A has rank r iff it has r linearly independent columns, analogous results for rows. Linear homogeneous and non- homogeneous equations, inner product of two vectors, orthogonal and unitary matrices, determination of orthogonal matrices.

Vector spaces, examples, subspaces, algebra of subspaces, quotient spaces, linear dependence, independence and linear span of vectors, basis and dimensions of vector spaces.

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations, dual space and dual basis, homomorphism and isomorphism, isomorphism theorems.

THEORY OF PROBABILITY

The probability set functions, its properties, probability density function, the distribution function and its properties, mathematical expectations, some special mathematical expectations, inequalities of Markov, Chebyshev and Jensen.

Conditional probability, independent events, Baye's theorem, distribution of two and more random variables, marginal and conditional distributions, conditional means and variances, correlation coefficient, stochastic independence and its various criteria.

Some Special Distributions, Bernoulli, Binomial, trinomial, multinomial, negative binomial, Poisson, gamma, chi-square, beta, Cauchy, exponential, geometric, normal and bivariate normal distributions.

Recommended Books:
1. Hogg and Craig, An Introduction to Mathematical Statistics.
2. C. R. Rao, Linear Statistical Inference and its Applications.
3. S.P.Gupta: Statistical Methods. Sultan Chand and sons.
4. S.C Gupta and V.K Kapoor (2007): Fundamentals of Mathematical Statistics, Sultan Chand and sons.
5. Freund J.E (2001): Mathematical Statistics, Prentice Hall of India.

6. Murthy M.N (1967): Sampling theory and Methods, Statistical Publisher Society, Calcutta.
7. Croton F.E and Cowden D.J (1969): Applied General Statistics, Prentice Hall of India.
8. Gupta and Mukhopadhay P.P: Applied Statistics, Central Book Agency.
9. G.B. Thomas and R. L. Finney, Calculus, Pearson Education, 2007.
10. E.G.Philips, Functions of a complex Variable.
11. Schaum Series, Differential Equations.
12. R.G.Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) P. Ltd., 2000.
13. Shanti Narayan, A Text Book of Matrices.
14. S.C Malik, Mathematical Analysis, Narosa publications.
15. S. Singh and Q. Zameer Din, Modern Algebra.
16. Shanti Narayan, Analytical Solid Geometry.