No. 945

Price : Re. One only

University of Poona

Semester Courses in Statistics at M.A./M.Sc.

Any person who has taken the Degree of Bachelor of Arts (Special) or the Degree of Bachelor of Science with Statistics as the science subjects at the B.A. (Special) or B.Sc. (Principal) Examination or as one of the subjects at B.Sc. (General) with at least 55% marks in the Statistics from this University or an equivalent degree of any other Statutory University or Body recognized by the University of Poona as equivalent thereto, will be held eligible for the admission to the M.A./M.Sc. Degree Courses.

Notwithstanding the above provisions, a student will be held eligible to join the M.A./M.Sc. Degree Course in Statistics if he has passed, at least in second class, M.A./ M.Sc. Degree Examination with Mathematics or Biometry.

The entire course in Statisticas shall consist of twenty semester courses, each carrying 100 marks out of which 40 marks are reserved for semester work; out of these 20 courses, 12 will be University Courses and 8 will be Departmental Courses. The end of the term examination for a University Course will be conducted by the University of Poona and that for Departmental Courses will be conducted by the Department of Statistics, University of Poona.

At the commencement of the third semester, a student, in consultation with the Departmental Staff Committee, will choose one area of specialization from the four areas listed below.

Area of Specialization	*Number Code*
1. Probability	1
2. Mathematical Statistics	2
3. Applied Statistics	3
4. Biostatistics	4

The above areas of specializations denoted by Number Code 1, 2, 3, 4 will be referred to as Module I, Module II, Module III, and Module IV respectively.

The following notation comprising two letters and three digits is used to lable courses :

1. In every lable the first two letters, ST, stand for Statistics.
2. The third symbol or the first numeral in the lable, following the two letters ST, is 7, 8, 9, or 0. The number 7, 8, 9 and 0 are used for the first, second, third and fourth semester respectively.
3. The fourth symbol or the second numeral in the lable is 0 or 1 for a University Course. The fourth symbol is 2,3,4 and 5 for the Departmental courses in the Module-I, Module-II, Module-III and Module-IV respectively.
4. The fifth symbol or the third numeral in the lable is for listing the course.

Thus ST 901 will refer to the first University course in the third semester whereas ST 022 will refer to the second Departmental course in the fourth semester for Module-I.

List of University Courses for all Modules.

The First Semester

ST 701 : Mathematical Analysis—I.
ST 702 : Mathematical Analysis—II.
ST 703 : Linear Algebra.
ST 704 : Probability Distributions.
ST 705 : Sampling Theory.

The Second Semester

ST 801 : Elements of Probability Theory.
ST 802 : Elementary Stochastic Processes.
ST 803 : Parametric Inference.
ST 804 : Linear Models.
ST 805 : Multivariate Analysis.

The Third Semester

ST 901 : Practicals—I.

The Fourth Semester

ST 001 : Practicals—II.

List of Departmental Courses :

Note that there are no departmental courses for any module for the *first two* semesters.

Module I : Probability.

The Third Semester

ST 921 : Asymptotic Inference
(Common to all modules)
ST 922 : Measure Theory and Integration
(Common with ST 932)
ST 923 : Probability—I
(Common with ST 934)

Any one course from those provided by the Department out of the following optional courses :

ST 924 : Stochastic Processes—I.
ST 925 : Characteristic Functions.
ST 926 : Functional Analysis.

The Fourth Semester

ST 021 : Computer Oriented Statistical Methods
(Common to all modules)
ST 022 : Stochatic Models
(Common with ST 044)
ST 023 : Probability—II.

Any one course from those provided by the Department out of the following optional courses :

ST 024 : Inference in Stochastic Processes
(Common with ST 034)
ST 025 : Characterization of Distributions.
ST 026 : Stochastic Processes—II.

Module II : Mathematical Statistics.

The Third Semester

ST 931 : Asymptotic Inference
(Common to all modules)
ST 932 : Measure Theory and Integration
(Common with ST 922)
ST 933 : Multivariate Analysis—II
(Common with ST 944, ST 954)

Any one course from those provided by the Department out of the following optional courses :

ST 934 : Probability—I.
(Common with ST 923).
ST 935 : Unified Sampling Theory.
ST 936 : Bayesian Inference.
(Common with ST 946)

The Fourth Semester

ST 031 : Computer Oriented Statistical Methods.
(Common to all modules)
ST 032 : Advanced Inference.
ST 033 : Decision Theory.

Any one course from those provided by the Department out of the following optional courses :

ST 034 : Inference in Stochastic Processes.
(Common with ST 024)
ST 035 : Nonparametric Inference.
(Common with ST 045, ST 055)
ST 036 : Sequential Analysis.
ST 037 : Advanced Linear Models.
(Common with ST 047, ST 054)

Module III : Applied Statistics.

The Third Semester

ST 941 : Asymptotic Inference.
(Common to all modules)
ST 942 : Operations Research—I.
ST 943 : Industrial Statistics.

Any one course from those provided by the Department out of the following optional courses :

ST 944 : Multivariate Analysis—II.
(Common with ST 933, ST 954)
ST 945 : Discrete Data Analysis.
(Common with ST 955)
ST 946 : Bayesian Inference.
(Common with ST 936)

The Fourth Semester

ST 041 : Computer Oriented Statistical Methods.
(Common to all modules)
ST 042 : Time Series Analysis.
ST 043 : Econometrics.

Any one course from those provided by the Department out of the following optional courses :

ST 044 : Stochastic Models.
(Common with ST 022)
ST 045 : Nonparametric Inference.
(Common with ST 035, ST 055)
ST 046 : Operations Research- II.
ST 047 : Advanced Linear Models.
(Common with ST 037, ST 054)

Module IV : Biostatistics.

The Third Semester

ST 957 : Asymptotic Inference.
(Common to all modules)
ST 952 : Regression Analysis and Bioassays.
ST 953 : Statistical Genetics.

Any one course from those provided by the Department out of the following optional courses :

ST 954 : Multivariate Analysis- II.
(Common with ST 933, ST 944)
ST 955 : Discrete Data Analysis.
(Common with ST 945)

The Fourth Semester

ST 051 : Computer Oriented Statistical Methods.
(Common to all modules)
ST 052 : Demography.
ST 053 : Epidemiology.

Any one course from those provided by the Department out of the following optional courses :

ST 054 : Advanced Linear Models.
(Common with ST 037, ST 047)
ST 055 : Nonparametric Inference.
(Common with ST 035, ST 045)
ST 056 : Medical and Public Health Statistics.

SEMESTER I

ST 701 : **Mathematical Analysis- I.**

Countability, supremum and infimum of sets of real numbers. Limit points of a set, open and closed sets, Bolzano-Weierstrass theorem, Heine-Borel theorem, uniform continuity.

Sequences and series of real numbers, limit superior, limit inferior and limit of a sequence, Cauchy soquences, convergence of series, tests for convergence of series, absolute convergence, Cauchy products.

Riemann and Riemann-stieltjes integrals, integration by parts, mean value theorems.

Uniform convergence of sequences and series. Term by term differentiation and integration, applications to power series.

Uniform convergence of integrals, differentiation under the sign of integral-Leibniz rule.

Books Recommended

1. Apostol, T. M. ..Mathematical Analysis.
2. Bartle, R. G. ..Elements of Real Analysis (Wiley)
3. Olmstead, John, H. M. ..Advanced Calculus.
4. Rudin, W. ..Principles of Mathematical Analysis.

ST 702 : Mathematical Analysis—II.

Complex numbers-their elementary properties. Functions of complex variables—Analyticity, Cauchy-Riemann equations.

Contour integration—Cauchy's theorem, Cauchy's integral Formulae, Power series, Taylor and Laurent expansions, residue theorem and its applications.

Finite dimensional Eucpidean spaces-real valued functions of several variables, continuity, differentiability, maxima and minima of functions of several variables, Lagrangian multipliers. Taylor's expansions.

Multiple integrals, Transformations on higher dimensional spaces, Jacobian of a transformation, its properties and use in evaluating multiple integrals.

Infinite and improper integrals, convergences of beta, gamma and Dirichlet's integrals, Laplace and Fourier transforms and their elementary properties.

Books Recommended

1. Bartle, R. G. ..Elements of Real Analysis (Wiley)
2. Churchill, R. V. ..Complex variables and applications.
3. Kreyszig, E. ..Advanced Engineering Mathematics (Wiley Eastern).
4. Olmstead, John, M. H. ..Advanced Calculus.
5. Rudin, W. ..Principles of Analysis.

ST 703 : Linear Algebra.

Orthogonal and idempotent matrices.

Linear dependence, basis of a vector space, an orthogonal basis, Gram-Schmidt Orthoganlization, linear transformation; Rank of a matrix; Linear equations, solution space and null space.

Characteristics roots of real matrices, right and left characteristic vectors, independence of characteristic vectors corresponding to distinct characteristic roots, algebraic and geometric multiplicities; Generalized inverse.

Definiteness of a real quadratic form, reduction of quadratic forms, Simultaneous reduction of two quadratic forms, maxima and minima of ratios of two quadratic forms.

Books Recommended

1. Graybill, F. E. ..Introduction to Matrices with Applications in Statistics.
2. Hohn, F. E. ..Elements of Matrix Algebra.
3. Rao, C. R. ..Linear Statistical Inference and its applications.

Additional Book for Reference

1. Bellman, R. . Introduction to Matrix Analysis.

ST 704 : Probability Distributions.

Univariate and Multivariate : discrete and continuous distributions, Marginal and conditional distributions. Probability generating functions, Compound distributions (Techniques based on probability generating functions).

Multiple Regressions, Multiple and partial correlations. Distributions of linear and quadratic forms in independent, identically distributed, Standard normal variables (Techniques based on moment generating functions), Cochran's theorem.

Joint distributions of order Statistics and its applications.

Books Recommended

1. Cramer, H. ..Mathematical Methods in Statistics.
2. Fisz, M. ..Probability and Mathematical Statistics.
3. Hogg, R. V. and Craig, A. T. ..Introduction to Mathematical Statistics.

Additional Books for Reference

1. Johnson, N. L. and Kotz, S. ..Distributions in Statistics : Continuous Multivariate Distribution.
2. Rohatgi, V. K. ..Introduction to Probability Theory and Mathematical Statistics.

ST 705 : Sampling Theory.

Basic methods of sample selection, simple random sampling with replacement, simple random sampling without replacement, probability proportional sampling with and without replacement, systematic sampling, estimation problems, Horwitz—Thompson estimator and its properties.

Stratification : Allocation problems and estimation problems, formation of strata and number of strata, method of collapsed strata.

Use of supplementary information for estimation, ratio and regression estimators with their properties and generalizations.

Cluster sampling, multi-stage sampling.

Double sampling procedures, uses of ratio and regression estimators, stratification.

Non-sampling errors, response and non-response errors and their treatments.

Book Recommended

1. Des, Raj . Sampling Theory.

Additional Books for Reference

1. Murthy, M. N. .Sampling Theory and Methods.
2. Sukhatme, P. V. and Sukhatme, B. V. ..Sampling Theory of Surveys and applications.

SEMESTER II

ST 801 : Elements of Probability Theory.

Algebra of sets, fields and Sigma-fields, limits of sequences of subsets, sigma-field generated by a class of subsets, Borel fields.

Probability measure on a sigma-field, probability space, continuity of probability measure, real and vector valued random variables, induced probability measure, distribution functions, independence.

Expection of a random variable, Important properties of expectation, Markov and Chebychev Inequalities. Characteristic functions and their properties.

Sequence of idependant random variables, convergence in probability and in quadratic mean, weak laws of large numbers, convergence in distribution, Central limit theorem for independent random variables in Liapunov's form, Cramer's theorem on composition of convergence in distribution and convergence in probability.

Books Recommended

1. Chung, K. L. ..Course in Probability Theory.
2. Eisen, M. ..Introduction to Mathematical Probability Theory.
3. Tucker, H. G. ..Graduate Course in Probability.

Additional Books for Reference

1. Gnedenko, B. V. ..Theory of probability.
2. Loeve, M. ..Probability Theory.

ST 802 : Elementary Stochastic Processes.

Markov chains with stationary transition probabilities, properties of transition functions, classificarion of states, Stationary distribution of a Markov chain, existence and uniqueness, convergence to the stationary distribution.

Markov pure jump processes, Poisson process, Birth and death process.

Second order processes, mean and covariance function, Gaussian and Wiener processes.

Stochastic differential equations, estimation theory and spectral distributions'.

Book Recommended

1. Hoel, P. C., Port, S. C. and Stone, C. J. ..Introduction to Stochastic Processes.

Additional Books for Reference

1. Feller, W. ..An Introduction to Probability Theory and its Applications, Vol. I (Third Edition)
2. Karlin, S. and Taylor, H. M. ..A First Course in Stochastic Processes (Second Edition).
3. Parzen, E. ..Stochastic processes.

ST 803 : Parametric Inference.

Sufficiency, completeness, and Uniformly minimum variance unbaised estimators, exponential class of densities and its properties, some special classes of distributions admitting complete sufficient statistics, extensions of these results to multi-parameter situation.

Test function, Neyman Pearson lemma for test functions. Uniformly most powerful tests for one sided alternative for one parameter exponential class of densities and extension to the distributions having monotone likehood ratio property.

Confidence Intervals, shortest expected length confidence intervals, relations with testing of hypotheses, uniformly most accurate confidence intervals.

Books for Reference

1. Dudewicz, E. J. ..Introduction to Statistics and Probability.
2. Roussas, G. G. .First Course in Mathematical Statistics.
3. Silvey, S. D. ..Statistical Inference.
4. Wilks, S. S. ..Mathematical Statistics.

ST 804 : Linear Models.

Gauss-Markov model, estimability of a linear parametric function, best linear unbaised estimator, Gauss-Markov theorem, Testing of linear hypothesis.

Applications of Gauss-Markov theory for analysis of two way designs, completely randomized design, randomized block design, Latin square design, and balanced incomplete block design. Balance, connectedness and orthogonality in relation to two way designs. Missing plot technique, analysis of covariance.

Factorial experiments, confounding and fractional replication in 2n factorial experiments.

Books Recommended

1. Chakrabarti, M. C. ..Mathematics of Design and Analysis of Experiments.
2. John, P. W. M. Statistical Design and Analysis of Experiments.
3. Rao, C. R. ..Linear Statiatical Inference and its Applications.

Additional Books for Reference

1. Dunn, O. J. and Clark, V .Applied Statistics.
2. Ogawa, J. ..Statistical Theory of the Analysis of Experimental Design.

ST 805 : Multivariate Analysis I.

Singular and nonsingular multivariate normal distributions, their properties, quadratic forms in multivariate normal vectors.

Maximum likehood estimators of the parameters of a multivariate normal distributions, their sampling distributions.

Wishart distribution and its properties.

Tests of hypotheses about the mean vector of a multinormal population, Hotelling's T^2 statistics, its distribution, applications of Hotellings' T^2.

Maximum likehood estimators of partial and multiple correlation coefficients their sampling distributions.

Classification problem (Bayes approach is not expected) Discriminant Analysis, Mahalanobis' D^2—statistics. Introduction to principal component and canonical correlation analysis.

Books Recommended

1. Anderson, T. W. ..Introduction to Multivariate Analysis.
2. Kshirsagar, A. M. ..Multivariate Analysis.
3. Morrison, D. F. ..Multivariate Statistical Methods.
4. Rao, C. R. ..Linear Statistical Inference and its Applications.

Semester III

ST 901. Practicals I

Practicals based on the following topics :

1. Solving linear equations; vector spaces.
2. Computation of characteristic roots and vectors of a matrix, powers of a stochastic matrix.
3. Orthogonal matrices : Orthogonalization, completing an incomplete orthogonal matrix.
4. G inverse of matrices and their applications in linear estimation.
5. Quadratic forms; rank, signature, reduction to canonical form, computation of $x' A^{-1} x$.
6. Linear estimation.
7. Analysis of two way data.
8. BIBD.
9. Analysis of covariance.
10. Missing plot technique.
11. Factorial experiments.
12. Stratified sampling.
13. Ratio method of estimation.
14. Regression method of estimation.
15. Cluster sampling.
16. Two-stage sampling.
17. Probability Proportional sampling.
18. Systematic sampling.

(*Note* :—The practicals as far as possible be based on live data and emphasis would be on analysing the data from various view points.)

ST 921, ST 931, ST 941, ST 951. Asymptotic Inference.

Consistency (mean squared and weak), invariance of consistency under continuous transformation, consistency for several parameters, generating consistent estimators using weak law of large numbers. CAN estimators (single as well as multiparameter cases), invariance of CAN estimators under differentiable transformations, generation of CAN estimators using central limit theorem.

Method of moments, method of maximum likelihood, Special cases such as exponential class of densities and multinomial distribution, Cramer-Huzurbazar theorem, method of scoring.

Likelihood ratio tests, asymptotic distribution of log likelihood ratio, applications including contingency tables.

Books for Reference

(1) Cramer, H. — Mathematical Methods in Statistics.
(2) Rao, C. R. — Linear Statistical Inference and its Applications.
(3) Silvey, S. D. — Statistical Inference.
(4) Wilks, S. S. — Mathematical Statistics.

Semester IV

ST 001. Practicals II

Practicals based on the following topics :

1. Model sampling from multivariate populations.
2. Model sampling from mixtures; estimation and goodness of fit.
3. Realizations of Stochastic processes.
4. Multiple regression.
5. Orthogonal polynomials.
6. Censored samples, order statistics, estimation of parameters of an exponential distribution using order statistics.
7. Model Sampling from a multivariate normal populations, estimation of parameters.
8. Tests of hypotheses for mean of a normal vector, Hotelling's T^2
9. Tests of hypotheses for a vector of regression coefficients, multiple and partial correlations.
10. Applications of Hotelling's T^2.
11. Classification problem : discriminant function, applications of Mahalanobi's D^2.
12. Principal Components.
13. Canonical correlations and variates
14. Methods of Estimation.
15. Performance of tests of hypotheses, computing power functions of tests and plotting them.
16. Comparing mean square errors of different estimators.
17. Likelihood ratio tests
18. Analysis of contingency table, an $r \times s \times t$ contingency table.
19. Analysis of contingency table when cell probabilities are functions of parameter(s).

(*Note* :—Same as in ST 901.)

ST 021, ST 031, ST 041, ST 051. Computer Oriented Statistical Methods.

Basic properties of Fortran IV : Flow charting, Fortran constants and variables, Arithmetic expression, Input-output statements, control statements, Do statements, Subscripted variables, Functions and subroutines.

Designing of programmes for statistical methods such as data screening, multiple linear regression, analyis of variance and of contingency tables. Generating Random numbers.

Study of certain standard statistical packages.

Books Recommended

(1) Afifi, A. A. and Azen, S. P. ..Statistical Analysis—Computer Oriented Approach.
(2) McCracken, D. D. ..A Guide to Fortran IV Programming.
(3) Rajaraman V. ..Computer Programming in Fortran IV.

Additional Books for Reference

(1) Ramani, K. R. and Nagarajan ..Computer Programming.
(2) Steinbach, R. C. ..Programming Exercises.

Notes :—(1) In any module, additional optional (Departmental) courses may be provided at the discretion of the Head of the Department.

(2) In Semester III and IV in each module with the permission of the Head of the Department a student may select one or two interdisciplinary courses recognised by the University in lieu of the (Departmental) optional courses listed above.

(3) With the permission of Head of the Department a student may elect to work on a project in lieu of the two optional (Departmental) courses listed above. This option shall be exercised as the beginning of the third semester.

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