



PRICE B.10/-

**NORTH MAHARASHTRA UNIVERSITY
JALGAON - 425 001**

SYLLABUS

FOR

**M.Sc. STATISTICS
(with specialization in Industrial Statistics)**

W. E. F. JULY 1997

SEMESTER I TO IV

**DEPARTMENT OF STATISTICS
SCHOOL OF MATHEMATICAL SCIENCES**

NORTH MAHARASHTRA UNIVERSITY, JALGAON

DEPARTMENT OF STATISTICS

SCHOOL OF MATHEMATICAL SCIENCES

ADMISSION ELIGIBILITY:

The students securing minimum of 50% marks (45% for reserved category) at B.Sc. examinations in Statistics are eligible for admission to M.Sc. course in Statistics. Merit and reservation policy are the criteria for selecting students.

EXAMINATION PATTERN:

1. All courses except ST-105, ST-205, ST-305, and ST-405
Internal : 40 marks (2 Hours Examination)
(Theory)
External : 60 marks (3 Hours Examination)
(Theory)
2. ST-105 :
Internal : Theory : 20 marks (1 Hour Examination)
40 marks Practical : 20 marks (1 Hour Examination)
External : Theory : 30 marks (1 1/2 Hours Examination)
60 marks Practical : 30 marks (1 1/2 Hours Examination)
3. ST-205 and ST-305 :
Internal : 40 marks (2 Hours Examination)
(Practical)
External : 60 marks (3 Hours Examination)
(Practical)
4. ST-405 :
Internal : 40 marks (Project Report 30 marks
(Project) viva-voce 10 marks)
External : 60 marks (3 Hours Examination)
(Practical)

STANDARD OF PASSING :

To pass any course, the candidate has to secure at least 40% marks in the internal as well as in the external examinations.

The candidate failed in Internal or External or in both examinations shall have to appear for subsequent Internal or External or both Examinations respectively for that course.

The student having the backlog of any course(s) from first year of M.Sc. can be admitted to second year of M.Sc.

NORTH MAHARASHTRA UNIVERSITY, JALGAON

M.Sc. STATISTICS (with specialisation in Industrial Statistics)

COURSE STRUCTURE

Code No.	Course Title	No. of lectures	
		Theory	Practical
SEMESTER-I			
ST 101	Mathematical Methods	45	--
ST 102	Linear Algebra	45	--
ST 103	Sampling Theory	45	--
ST 104	Probability Distributions	45	--
ST 105	Introduction to Computer Programming and Statistical Software Packages	30	30
SEMESTER-II			
ST 201	Elementary Stochastic Processes	45	--
ST 202	Parametric Inference	45	--
ST 203	Multivariate Analysis	45	--
ST 204	Theory of Probability	45	--
ST 205	Practicals - I	--	60
SEMESTER-III			
ST 301	Linear Models	45	--
ST 302	Asymptotic Inference	45	--
ST 303	Statistical Process Control-I	45	--
ST 304	Operations Research	45	--
ST 305	Practicals - II	--	60
SEMESTER-IV			
ST 401	Stochastic Models	45	--
ST 402	Advanced Statistical Methods	45	--
ST 403	Optional Course - I	45	--
ST 404	Optional Course - II	45	--
ST 405	Practicals - III and Project	--	40

List of Optional Courses :

1. Statistical Process Control - II
2. Reliability and Life Testing
3. Time Series.

Note : Additional optional courses may be introduced from time to time by the Head of Department with the approval of the Board of Studies in Statistics.

DETAILED SYLLABI

ST-101 : MATHEMATICAL METHODS

Countability; Supremum and infimum of sets of real numbers; Limit points of set; Open and closed sets; Bolzano - Weierstrass and Heine-Borel theorems (without proofs); Continuity and uniform continuity.

Sequences and series of real numbers; Limit superior, limit inferior and limit of a sequence; Cauchy sequences; Convergence of series; Tests for convergence of series; Absolute convergence.

Riemann integral; Integration by parts; Mean-value theorems; Term by term differentiation and integration; Applications to Power Series; Improper integrals of the first and the second kind; Uniform convergence of sequences, series and improper integrals; Differentiation under the integral sign; Leibnitz Rule.

Linear transformation of the Euclidean n -space; Differentiability of functions of several variables; Chain rule; Partial and directional derivatives; Taylor's formula (without proof); Inverse function theorem, Implicit function theorem (without proof).

Books Recommended

1. Rudin. W. : Principles of Mathematical Analysis
2. Apostol T. M. : Mathematical Analysis
3. Bartle R. G. : Real Analysis
4. Goldberg : Real Analysis

ST-102 : LINEAR ALGEBRA

Matrix algebra, special types of matrices, determinants and their simple properties.

Orthogonal and idempotent matrices.

Linear dependence, basis of a vector space, and orthogonal basis, Gram-Schmidt Orthogonalization, Projection Theorem, Linear transformation; Rank of matrix; Linear equations, solution space and null space.

Characteristic 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 real quadratic forms; reduction of quadratic forms; Simultaneous reduction of two quadratic forms; maxima and minima of ratio of two quadratic forms.

Books Recommended

1. Graybill, F.E. Introduction to Matrices with Applications in Statistics
2. Rao, C. R. Linear Statistical Inference and its Applications.
3. Senrle, S. R. Matrix algebra useful for Statistics.
4. Bellman, R. Introduction to Matrix Analysis

ST-103 : 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.

Use of Auxiliary information for estimation; ratio and regression estimators with their properties and generalizations; Jack-knife method.

Cluster sampling, multi-stage sampling.

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

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

Books Recommended

1. Desraj : Sampling Theory
2. Sukhatme P. V., Sukhatme B. V., : Sampling Theory of Surveys and
Sukhatme S. R. & Ashok C. Applications
3. Cochran W. G. : Sampling Techniques.

ST-104 : PROBABILITY DISTRIBUTIONS

Random Experiment and its sample space, random variables, c.d.f., p.d.f., p.m.f., absolutely continuous and discrete distributions, mixtures of probability distributions. Some common distributions. Transformations, moments, m.g.f., p.g.f., quartiles and symmetry. Random vectors, joint distributions, joint m.g.f., variance covariance matrix. Independence, sums of independent random variables, conditional expectation and variances, regression function and best linear regression function, multiple regression, multiple and partial correlation.

Sampling distribution of statistics from univariate normal random samples.

Distribution of linear and quadratic forms in i.i.d. standard normal variables (Techniques based on moment generating functions), Cochran's theorem.

Order statistics : distribution of r-th order statistics, joint distribution of several order statistics and their functions.

Books Recommended

1. Hogg, R.V. and Craig, A. T. : Introduction to Mathematical Statistics
2. Rohatgi, V. K. : Introduction to Probability Theory
and Mathematical Statistics
3. C. R. Rao : Linear Statistical Inference
and Its Applications
4. Cramer H. : Mathematical Methods of Statistics.

ST-105: INTRODUCTION TO COMPUTER PROGRAMMING AND STATISTICAL SOFTWARE PACKAGES

Introduction to computer and its components, Input/Output devices, Kinds of computers, Fields, records and files, Basic concepts of system software.

Introduction to C programming : Overview, Data types, Operators and expressions, Control flow - If-else, Else-if, switch, loops - While and for, do-while, break and continue, goto and labels. Functions and program structures. Pointer and arrays, Structures, Input and output - Formatted output, formatted input, File access.

Introduction to DOS and Windows.

Introduction of commonly available statistical packages such as Minitab, Matlab, Lotus-123, SPCEX, SPSS etc.

Utilizations

Writing programs in C for the following :

1. Finding largest/smallest of given numbers using array and without array.
2. For arranging given numbers in Ascending/Descending order using array and without array.
3. Matrix Multiplication.
4. To find Transpose of a given Matrix.
5. Find $\sin(x)$ using Taylor's series and compare the obtained value using standard function.
6. Computing CDF's.

Books recommended

1. Kerningtan, B.W. & Ritchie D.M. : The C Programming Language
2. Affi, A.A.: Statistical Analysis: A Computer oriented approach
3. Grover, P.S.: Computer Fundamentals & Problem Solving.

(N.B. : Students may be encouraged to complete a mini project based on live statistical data as assigned by the teacher.)

ST-201 : ELEMENTARY STOCHASTIC PROCESSES

Conditional probability and Expectations. Problems based on conditional probability, Markov chains with stationary transition probabilities, properties of transition probabilities, Classification of states, Stationary distribution of Markov chains, existence and uniqueness, convergence to the stationary distribution.

Markov pure jump processes, Poisson process, Birth and Death Processes, Application to Queuing, Inventory, Machine-Repairmen Problems, Branching Processes.

Books Recommended

1. Taylor and Karlin : An Introduction to Stochastic Modelling.
2. Medhi J. : Stochastic Processes.
3. Feller, W. : An Introduction to Probability Theory. Vol.I.
4. Hoel, P. C., Port, S. C., & Stone, C. JR. : Introduction to Stochastic Processes.
5. Ross, S.: Introduction to Probability Models.

ST-202 : PARAMETRIC INFERENCE

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

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 likelihood ratio property.

Confidence intervals, shortest expected length confidence intervals, relation with testing of hypothesis, uniformly most accurate confidence intervals.

Books Recommended

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
5. Lehmann E. L. : Testing of Statistical Hypothesis.
6. Lehmann E. L. : Theory of Point Estimation.
7. Rohatgi V. K. : Introduction to Theory of Probability and
Mathematical Statistics.

ST-203 : MULTIVARIATE ANALYSIS

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

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

Wishart distribution and its properties.

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

Maximum likelihood 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 components and canonical correlation-analysis, Introduction to Cluster Analysis & MANOVA.

Books Recommended

1. Anderson T.M. : Introduction to Multivariate Statistical Analysis
2. Kshirsagar A. M. : Multivariate Analysis.
3. Morrison D. F. : Multivariate Statistical Methods.
4. Rao C. R. : Linear Statistical Inference and its Application
5. Johnson R.A. & Wichern D.W. : Applied Multivariate Statistical Analysis
6. Muirhead : Aspects of Multivariate Statistical Theory

ST-204 : THEORY OF PROBABILITY

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

Probability measure on a sigma-field, probability space, continuity of a probability measure, Real and vector-valued random variable, distribution function (d.f.), discrete r.v.s., r.v.s. of the continuous type, decomposition of a l.f. Independence of two events, sequence of independent events, independent classes of events, independence of r.v.s., Borel zero-one law.

Expectation of a real r.v. and of a complex-valued r.v. Linear properties of expectations, moment inequalities, characteristic functions and their simple properties.

Convergence of sequence of r.v.s., convergence in distribution, convergence in probability, almost sure convergence and convergence in quadratic mean, their inter-relations, Khintchin's weak law of large numbers, Kolmogorov strong law of large numbers (without proof), monotone convergence theorem and dominated convergence theorem, continuity theorem for characteristic functions. Lindeberg's of convergence in distribution and convergence in probability.

Books Recommended

1. Bhat B. R. : Modern Probability Theory.
2. Chang K. L. : Course in Probability Theory.
3. Gnedenko B. V. : Probability Theory.
4. Billingsley : Probability and Measure.

ST-205 : PRACTICALS-I

Practicals based on ST-102, ST-103, ST-104, ST-201.

(Using statistical software packages and computer programing)

List of Practical:

1. Computation of inverse of a given matrix.
a) natural inverse b) g-inverse, c) Moore-Penrose inverse.
2. Solving system of linear equations.

3. Computing higher order powers of a given matrix using spectral decomposition.
4. Diagonalization and triangulation of a given matrix.
5. Computation of the largest eigen value of a matrix without solving the determinantal equation (using iterative procedure).
6. Generation of random numbers from discrete, continuous and mixture distributions.
7. Simple random sampling (with and without replacement)
8. Stratified random sampling.
9. Double sampling.
10. Cluster and systematic sampling.
11. Ratio regression method of estimation.
12. Horvitz-Thomson estimator and PPS and HPS designs.
13. Realization of Markov chain, branching process, Poisson process and random walk, calculation of probabilities in Markov chain.

ST-301 : LINEAR MODELS

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

Applications of Gauss-Markov theory for analysis of one and two way designs, completely randomized design, randomized block design. Balanced, connectness and orthogonality in relation to two way design. Missing plot technique, analysis of covariance. Factorial experiments, confounding. Application of Gauss-Markov setup to regression analysis.

Books Recommended

1. Kshirsagar, A. M. : Linear Models
2. Seale, S. R. : Linear Models
3. Montgomery : Design and Analysis of Experiments.
4. John P. W. N. : Statistical Design and Analysis of Experiments
5. Rao, C. R. : Linear Statistical Inference and its Applications
6. Dumas, O. J. and Clark, V. : Applied Statistics

ST-302 : 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 under differentiable transformations, generation of CAN estimators using central limit theorem.

Methods 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 Recommended

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
5. Ferguson T. S.: A Course in Large Sample Theory.

ST-303 : STATISTICAL PROCESS CONTROL-I :

1. ISO-9000, QS-9000 Quality systems standards.
2. Relation between Theory of Testing of Hypothesis and Control Charts.
3. Basic concepts of quality control, process control and process capability.
4. Control charts for measurements and attributes:
X-bar, R, s, p, c, np - charts with subgrouping, CUSUM charts, CUSUM procedure for controlling process variability. Comparison with Shewhart charts, Acceptance control charts.
5. Process capability indices :
Purpose of capability indices, determining process capability using X-bar, R-charts, role of normality in defective parts per million, one sided specification, non-normal distributions.

6. Sampling Inspection plans:

Dodge-Roming characterization by OC curve and ARL. Inspection by variables for one or two sided specifications.

Brief discussion on MIL-STD's.

7. Multivariate control charts for measurement data.

Books Recommended

1. Rayan T.P. : Statistical Methods for Quality Improvement
2. Weatherill, G.B. & Brown, D.W. : Statistical Process Control: Theory and Practice.
3. Hansen, B.L. & Ghare, P.M. : Quality Control and Applications.
4. John, W.M. : Statistical Methods in Engineering Quality Assurance
5. Guenther, W.C. : Sampling inspection in Statistical Quality Control.
6. D.C. Montgomery : Introduction to Statistical Process Control
7. S. Kotz & N.L. Johnson : Process Capability Indices.
8. Handbook of SQC SP 28 : 1994 (BIS Pub.)

ST 304 : OPERATIONS RESEARCH

Linear Programming : Graphical procedures; redundant activities, surplus resources; simplex algorithms theory and method; dual of a problem and properties of dual; dual simplex procedure, revised simplex procedure.

Applications of linear programming : transportation problem; assignment problem; maximum flow in a given network; shortest route problem; transshipment problem.

Integer programming; Pure LIPP; Mixed integer programming problem; branch and bound method, f - cut, elements of Dynamic Programming.

Books Recommended

1. Hadley, G. : Linear Programming and its Applications.
2. Tiha, H. A. : Operations Research an Introduction.
3. Gauss, S. I. : Linear Programming
4. Wagner : Principles of Operations Research
5. Kambo, N. S. : Mathematical Programming Techniques.
6. D. T. Phillips : Operations Research.

ST-305 : PRACTICALS-II

Practicals based on : ST-202, ST-203, ST-204, ST-302, ST-303, ST-304.

(Using statistical software packages and computer programming)

List of Practicals:

1. Model sampling from multivariate normal distribution.
2. Estimation of μ , Σ , matrix of correlation coefficients, multiple correlation coefficient. Test of significance of multiple and partial correlation coefficients.
3. Applications of Hotelling T^2 .
4. Discriminant Analysis and Classification problem.
5. Principal components.
6. Canonical correlation
7. Regression.
8. Application and verification of CLT and WLLN
9. a) Moment Estimation
b) M.L. Estimation.
10. Likelihood ratio tests.
11. LPP- Formulation of the LPP.
a) Solve the given LPP
b) Solve the given transportation problem.
12. Solve the given pure LIPP
13. a) For the given data (variable) establish stability using (\bar{x}, \bar{R}) chart and evaluate C_p , C_{pk}
b) For the given data (variable) establish stability using (\bar{X}, MR) chart and evaluate C_p , C_{pk}
c) For the given data (attribute) establish stability using p/c chart and evaluate capability.
14. a) Single/double sampling plans for attributes.
b) Single sampling plans for variable data. (one sided/two sided alternatives for mean).

ST-401 : STOCHASTIC MODELS

Elements of Renewal Theory & its applications.

Theory of Queues :

Queueing systems M/M/1, M/M/k, M/G/1 and GI/M/1.

Finite time solution for the system M/M/1, use of M/M/1.

Use of combinatorial methods in obtaining $P(t)$ for M/M/1. Regenerating points and embedded markov chains for the systems M/G/1 and GI/M/1. Stationary solution for M/M/1, M/M/k and M/M/ ∞ , ladder indices.

Inventory Models.

Single item static model, model with price breaks, multiple item model with storage limitation, single item n-period dynamic model, newsboy problem, (S,s) policy, application of renewal theory to the (S,s) - inventory model.

Books Recommended

1. Taha, H.A. : Operations Research- An Introduction
2. Tijms, H.C. : Stochastic Modeling and Analysis.
3. Medhi, J. : Introduction to Queuing Models.
4. Ross, S. : Introduction to Probability Models.
5. Taylor and : An Introduction to Stochastic Modelling.

Karlin

ST-402 : Advanced Statistical Methods

Robustness of a statistical procedure. Rank based tests : Mann-Whitney, Kruskal-Wallis, Freedman's tests for two-way ANOVA; Spearman's rank-correlation coefficient.

Efficiency, Asymptotic Relative Efficiency, Robustness and efficiency. AREs of standard non-parametric tests. Goodness of fit tests.

Regression analysis; test for normality of errors, diagnostic of regression model: heteroscedasticity. Non - linear regression analysis, Rank-based Regression analysis, Generalized linear models. Regression for Bernoulli Logistic, Poisson, Exponential and Gamma variables.

Elements of Categorical Data Analysis : Two-way and Three-way tables
Interaction, Symmetry, complete and Partial independence, Simpson's Paradox,
Association, odds Ratio, Introduction to log-linear models.

Books Recommended

1. Gore, Deshpande & Shanubhogue: Analysis of Non-normal Data.
2. Seber and Wild : Nonlinear Regression.
3. Feinberg : Categorical Data Analysis.
4. Cox and Snell: Applied Statistics.

ST-403 : OPTIONAL COURSE - I

ST-404 : OPTIONAL COURSE - II

ST-405 : PRACTICALS-III AND PROJECT

PRACTICALS-III :

Practicals Based on ST-301

1. Linear Estimation
2. (CRD)/RBD/LSD
3. Factorial designs and confounding
4. Missing-plot techniques.
5. Analysis of Covariance.
6. BIBD.

PROJECT :

Topics for the project will be given by the concerned teachers. Students have to work on project for the period of 3 months. In this Semester they will be given one day off per week for their industrial work/data collection/survey/field work etc.. Each student has to prepare a project report and submit it to the concerned teacher before the end of term examination. Project evaluation will be depending on project report and presentation by the student.

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