# SHIVAJI UNIVERSITY, KOLHAPUR.


**B**
**Accredited By NAAC**
**(2009)**
**New** Syllabus For

**M.Sc. Part - I (Sem I & II)**

## Statistics

## (For College level Course)

**Syllabus to be implemented from June 2010 onwards.**

**SHIVAJI UNIVERSITY,KOLHAPUR**

**M.Sc. (Statistics) syllabus (College level course) to be effective from the Academic Year 2010-2011.**

## STRUCTURE

The following table gives the scheme of Examination at M.Sc. Statistics according to the Revised Syllabus and pattern of Examination.

Notations : A six-character code is given to each paper. In MCST "M" stands for M.Sc., "C" stands for college level and "ST" stands for Statistics. The first digit following MCST is Semester Number. The second digit "0" stands for the compulsory theory paper., the digit "1" stands for a
practical paper and the digit "2" stands for an elective paper / project work. The third digit indicated the serial number of paper in that semester.

| Semester No. | Paper No. | Title of the Paper |
|---|---|---|
| I | MCST-101 | Statistical Mathematics I |
| | MCST-102 | Statistical Mathematics II |
| | MCST-103 | Distribution Theory |
| | MCST-104 | Estimation Theory |
| | MCST-105 | Statistical Computing |
| | MCST-116 | Practical I |
| II | MCST-201 | Probability Theory |
| | MCST-202 | Theory of Testing of Hypotheses |
| | MCST-203 | Multivariate Analysis |
| | MCST-204 | Linear Models & Design of Experiments |
| | MCST-205 | Sampling Theory |
| | MCST-216 | Practical II |
| III | MCST-301 | Reliability Theory |
| | MCST-302 | Elementary Stochastic Processes |
| | MCST-303 | Planning and Analysis of Industrial Experiments. |
| | MCST-304 | Regression Analysis. |
| | MCST-316 | Practical III |

**Elective Papers** from which **Any One** are to be chosen:

MCST -321 Asymptotic Inference
MCST -322 Demography
MCST -323 Advanced Stochastic Processes
MCST -324 Actuarial Statistics

| Semester No. | Paper No. | Title of the Paper |
|---|---|---|
| IV | MCST -401 | Optimization Techniques |
| | MCST -402 | Discrete Data Analysis |
| | MCST -403 | Industrial Statistics |
| | MCST -404 | Time Series Analysis |
| | MCST -416 | Practical IV & Project |

**Elective Papers** from which **Any One** are to be chosen:

MCST -421 Survival Analysis
MCST -422 Advanced Multivariate Analysis
MCST -423 Data Mining
MCST -424 Biostatistics

Note :-

a) The course will be divided in four semesters there will be five theory papers and one practical course in each semester.
b) There shall be CIE pattern in which internal examination will be for 20 marks of which 15 marks for mid semester test and **seminar for 25 marks** will be compulsory and marks scored will be distributed over the five theory papers. University examination will be for 80 marks.
c) Each theory course, there should be **four** lectures of 60 minutes each per week.
d) Each practical course be allotted 12 hours per week per batch of 10 students.

Proposed nature of the Theory and Practical Question Paper at the M.Sc. Statistics course under the Semester Schemes.

**1. Nature of the theory question papers**.
a) There shall be 7 questions each carrying 16 marks.
b) Question No.1 is compulsory and shall contain 10 short sub-questions each carrying 2 marks. Students have to attempt any 8 sub-questions.
c) Students have to attempt any 4 questions from question No. 2 to 7.
d) Question No. 2 to 6 shall contain 2 to 4 sub-questions.
e) Question No. 7 will be short note type. Students are expected to solve any 4 out of 6, each carrying 4 marks.

**2. Practical Paper :-**
a) Semester I,II,III " Practical MCST 116, MCST 216, MCST 316".
**Internal(20)** : There shall be 10 marks for day-to-day journal and internal test will be for 10 marks.
**End of Term Examination (80**): Practical Examination will be of 3 hrs. duration carrying 70 marks. There shall be 8 questions each of 14 marks, of which a student has to attempt any 5 questions.
VIVA will be for 10 marks.
**Note**: Use of appropriate software is expected. It is recommended that a soft copy of the data set be provided during practical examination, to save data input time. Emphasis will be

to test their knowledge in identifying a suitable statistical tool for analyzing the given data set and interpreting the results in the context of the relevant applications.
**Other rules will be applicable as per General M.Sc. Course.**

**MCST 101 : STATISTICAL MATHEMATICS - I**

1. Set of real numbers, countable and uncountable sets, countability of rationals and uncountability of the interval (0,1) Supremum and Infimum of bounded sets, limit points of a set, open, closed, dense and compact sets. Bolzano-Weierstrass and Heine-Borel Theorems (Statements only). Applications of these theorems. (10)

2. Sequence of real numbers, convergence, divergence. Cauchy sequence. Convergence of bounded monotone sequence. Limit inferior and limit superior of the sequences. (12)

3. Series of numbers, tests for convergence (without proof); tests for absolute convergence, convergence of sequences of non-negative terms. (6)

4. Real valued function, continuous function, Uniform continuity of sequence of functions, Uniform convergence of power series, radius of convergence. (4)

5. Vector and Matrix differentiation, Maxima, minima of functions of several variables. Constrained maxima, minima, Lagrange's method, Taylor's theorem (without proof) and its applications (4)

6. Riemann, Riemann-Steltjes Integrals. Integration by parts, mean value theorem, their applications in finding functions of distributions. (4)

7. Multiple integrals, Change of variables, Improper integrals, Applications in multivariate distributions. Uniform convergence, theorem on differentiation under integral sign (without proof), Leibnitz rule (statement only) and applications. (5)

References:

1. Malik S. C. & Arora S.(1991) : Mathematical Analysis- Wiley Eastern Limited IInd edition.
2. Goldberg R. R. (1964) : Methods of Real Analysis- Blaisdell Publishing company, New york, U.S.A.
3. Bartle G. R. ( 1976): Elements of Real Analysis- Wiley 2nd edition.
4. Bartle G.R. & Sherbert D. R. ( 2000): Introduction to Real Analysis- John Wiley & Son Inc.
5. Royden (1988) : Principles of Real Analysis - Macmillian.
6. Widder (1989) : Advanced Calculus - Dover Publication.
7 . Apostol ( 1985) : Mathematical Analysis - Narosa Publishing House, T.M.

8. Robert C Wrale & Murray R Spielgel :Schaum's outline of advanced calculus Series : (2nd Edition) .

**MCST 102 : STATISTICAL MATHEMATICS - II**

1. Vector space, subspace, linear dependence and independence, basis, dimension of a vector space, examples of vector spaces.

(8)

2. Null space, Special types of matrices: elementary operations, rank of a matrix. Orthonormal basis, and orthogonal projection of a vector. Gram-Schmidt orthogonalisation, Kronekar product. Idempotent matrices, inverse of a matrix, their simple properties, Partitioned Matrices, Orthogonal matrices.

(10)

3. Characteristic roots of a matrix, algebraic and geometric multiplicities, characteristic vectors and their orthogonal properties, spectral decomposition. Caley-Hamilton Theorem and applications.

(8)

4. G-inverse Moore – Penrose inverse, Solution of a system of homogenous and non-homogenous linear equations, and theorem related to existence of solution.

(10)

5. Quadratic forms: definition, reduction, simultaneous reduction of two quadratic forms, maxima and minima of ratio of quadratic forms.

(9)

References:

1. Rao A. R. & Bhimashankaram P. ( 1992) : Linear Algebra. Tata Mc-Graw Hill, New Delhi.
2. Hadely G (1987): Linear Algebra - Narosa Publishing House.
3. Rao C. R. ( 1973) : Linear Statistical Inference and Its Applications , Second Edition Wiley Eastern.
4. Searl S. B.(1982) : Matrix Algebra Useful for Statistics – Wiley
5. Graybill , F.A (1961) : An introduction to linear Statistical models Vol-IMcGraw-Hill Book company Inc.

**MCST 103 : DISTRIBUTION THEORY**

Unit-1: Brief review of basic distribution theory. Distribution function and its properties, Relation of distribution function with uniform distribution. Decomposition of distribution function into discrete and continuous parts.

(6)

Unit-2: Functions of random variables, their distribution in case of univariate random variables and its applications.

(6)

Unit-3: Expectation and moments, probability generating function, moment generating function, convolution and examples.

(5)

Unit-4: Moment inequalities:- Basic inequalities,Markov, Chebychev, Holder, Minkowski and Jensen inequalities with their applications.

(6)

Unit-5: Bivariate discrete and continuous distributions, marginal distributions. Examples of many joint with given marginal distributions. Independence, conditional , distributions and examples. Distribution of function of bivariate random variables using Jacobian of transformation.

(10)

Unit-6: Multinomial distribution, Bivariate Poisson,Bivariate normal distribution and their properties .

(6)

Unit-7: Symmetric distributions, properties of symmetric distributions, nonregular families, location and scale families and examples.

(3)

Unit-8: Order Statistics- distribution of $i_{th}$ order statistics, joint distribution of $(i,j)_{th}$ order statistics, independence of exponential spacing & examples.

(3)

References:

1. Rohatagi V.K.& Saleh A. K. Md. E.(2001) : Introduction to Probability Theory and Mathematical Statistics- John Wiley and sons Inc.
2. Johnson N. L. & Kotz. S. (1996) : Distributions in Statistics Vol-I,II and IIIJohn Wiley and Sons New york.
3. Johnson N.L. & S. Kotz. John : Multivariate Distributions - Wiley and sons New york.
4. Casella & Berger (2002) : Statistical Inference - Duxbury advanced series. $II_{nd}$ edition

**MCST 104 : ESTIMATION THEORY**

1. Sufficiency principle, factorization theorem, minimal sufficiency, minimal sufficient partition, construction of minimal sufficient statistics, minimal sufficient statistic for exponential family, power series distribution and non regular families.

(10)

2. Completeness, bounded completeness, ancillary statistics, Basu's theorem and applications.

(7)

3. Problem of point estimation, unbiased estimators, minimum variance unbiased estimator, Rao- Blackwell theorem and Lehmann-Scheffe theorem and their uses. Necessary and sufficient condition for MVUE and their applications.

(8)

4. Fisher information and information matrix, Cramer-Rao inequality, Chapmann-Robinson bounds, Bhattacharya bounds, their applications.

(6)

5. Method of maximum likelihood (MLE) and small sample properties of MLE, method of scoring and application to estimation in multinomial distribution.

(7)

6. Other methods of estimation: method of moments, minimum Chi square.

(3)

7. Bias reduction methods, Jack-Knife estimator-its properties and limitations. Boot – Strap method and its simple properties.

(4)

References

1. Rohatgi V.K.(1976): Introduction to Probability Theory & Mathematical Statistics - John Wiley & sons.
2. Lehmann E. L. (1983) : Theory of Point Estimation - John Wiley & sons.
3. Rao C. R.(1973) : Linear Statistical Inference & its Applications, $2_{nd}$ Ed wiley.

4. Kale B.K. (2005) : First Course on Parametric Inference, A , 2nd Edition.
Narosa Publishing House.
5. George Casella, Roger L. Berger (2001) : Statistical Inference (second
edition). Duxbury press.
6. Parimal Mukhopadhyay : Mathemathical statistics,Books & Allied (P) Ltd.
7. Dudwitz and Misrsa: Mathematical Statistics : John Wily & Sons New York.

**MCST 105: STATISTICAL COMPUTING**

1. Concept of random number generator, congruential method of generating uniform variate. (3)
2. Concept of simulation: Generation of Binomial, Poisson, Geometric, Negative Binomial & Multinomial variate. Proofs of related results. (5)
3. Generation of continuous random variables covering Exponential, Normal, Gamma, Chi-square, Bivariate Normal distributions, and mixture of distributions. (10)
4. . Excel: Introduction to MSEXCEL and exercises on using EXCEL for Statistical analysis covering frequency distribution, histograms, t-test, test for Independence in 2x2 contingency tables. (6)
5) MiniTAB : Discriptive statistics and graphical tools ANOVA and regression analysis. (6)
6) R –Software : Introduction to R , Simple commonds and matrix methods including g- inverse and spectral decomposition. (7)
7) Evaluation of numerical methods using R i) Newton Ramson method and regula falsi method. II) Numerical integration : Trapezoidal Rule , Simpson rule for single and double integrals. iii) solution of simultaneous equation. (8)

References

1. Morgan B. J. T.(1984) : Elements of Simulation. Chapman and Hall.
2. Kennedy William J.,Jr. james E.Gentle. (1980) : Statistical Computing Marcel
Dekker , Inc. New york and Basel.
3. Christion P. Robert, George casella (1999) : Monte carlo Statistical Methods,
Springer-verlag, New York, Inc.
4. Luc Devroye (1986) : Non- Uniform Random Variate Generation; Springer-
Verlag New York Berlin-Heidelberg Tokyo.
5. Rubinstein, R. Y. (1998)Modern Simulation and Modeling (Wiley Series in
Probability and Statistics)
6. Dr. Suda Purohit : Statistics using R- Software
7) S.S. Sastry ; Introductory methods of Numerical Analysis, PHI Learning Private Ldt, New Delhi. (2009)
8) E.V. Krishna Murthy & S.K. Sen ; Numerical Algorithm, East – West Publishers.
9) V. Rajaraman 1993 Computer Oriented Numerical methods Fourth Edi.(Prentice Hall)
10) Sheldon Ross : A first course in Probability ( Pearson Education)

**MCST 116: PRACTICAL –I**

1. Linear dependence of Vector and rank a matrix.
2. Gram-Schmidt orthogonalisation method.
3. Solving systems of equations, Inverse and g-inverse of a matrix.
4. Applications of Caley-Hamilton theorem.
5. Inverse of a Partitioned matrix.
6. Characteristic roots and vectors and their applications.
7. Classifications and reduction of quadratic forms.
8. Sketching of d.f and p.d.fs.

9. Model sampling from univariate discrete distributions .
10. Model sampling from bivariate discrete distributions
11. Model sampling from univariate continuous distributions .
12. Model sampling from bivariate continuous distributions .
13 Construction of UMVUE.
14. Methods of Scoring.
15. Bootstrap and Jack knife technique
16- 24 Programing assignments on MCST -105 course

## MCST 201: PROBABILITY THEORY

1. Classes of sets: Sequence of sets: limsup, liminf and limit of sequence of sets field, σ-field, σ-field generated by a class of set, Borel σ-field. (5)
2. Probability measure, Probability space, properties of probability measure – continuity, mixture of probability measures. Lebesgue and Lebesgue - Steltjes measures on R. Independence of events. (5)
3. Measurable function, random variable, distribution function of a random variable, simple random variable, elementary random variable liminf, limsup and limit of sequence of random variables. Method of obtaining a random variable as a limit of sequence of simple random variables. (10)
4. Integration of a measurable function with respect to a measure, expectation of a random variable, monotone convergence theorem, Fatous Lemma, Dominated Convergence theorem and their application. (5)
5. Convergence of sequence of random variables; Almost sure convergence, convergence in probability and their properties. Yule Slutsky results and preservation under continues transform.(Statements only), convergence in $r^{th}$ mean, interrelationships. (10)
6. Independence: Borel - Cantelli Lemma, Characteristic function simple properties. Inversion theorem and uniqueness property(Statement only). (5)
7. Convergence in distribution, continuity theorem (Statement only), Weak and Strong laws of large numbers, Kolmogorov's three series theorem for almost sure convergence(Statement only), Liaponove's, Lindeberg-Feller Theorems on CLT (Statement only). Applications of the above results. (5)

References:


1. Bhat B. R.(1981) : Modern Probability Theory –III$^{rd}$ edition :New age international (P)limited,
2. Alan Karr,(1993) : Probability Theory – Springer Verlag.
3. Billingsley P.(1986) : Probability & Measure –John Wiley and sons


## MCST 202 : THEORY OF TESTING OF HYPOTHESES

1. Problem of testing of Hypothesis : Simple and composite hypotheses. Randomized and non-randomized tests. Most powerful test, Neyman-Pearson Lemma and its applications. Determination of minimum sample size to achieve the desired strengths. (10)
2. Composite hypotheses : Monotone likelihood ratio property, power function of a test, existence of UMP. Tests for one-sided alternatives. UMP tests for two sided alternatives Examples. Their existence and non-existence. (10)

3. Generalized Neyman Pearson lemma : Unbiased test, UMPU test and their existence in the case of exponential families ( Statements of the theorems only). Similar tests, test with Neyman structure.

(8)

4. Problem of confidence intervals. Relation with testing of hypotheses problem, Uniformly Most Accurate(UMA) and UMAU confidence intervals, shortest length confidence intervals.

(8)

5. Likelihood ratio test. Application to standard distribution , application to contingency table.

6. Non-parametric tests. One and two sample problem; tests on U-Statistics for various hypotheses; the asymptotic distributions of the statistics involved under the null hypotheses (Statements of the theorems only). Sign test, Run test, Signed-Rank test, Wilcoxon Signed-Rank test, Man-Whiteny test.
(6)

7. Goodness of fit tests based on Chi-square distribution. Application to contingency tables.

(3)

References:


1. Kale B.K. (1999) : A First Course on parametric Inference. Narosa , II$^{nd}$ Edition.
2. Rohatgi V.K. (1988): Introduction to Probability and Mathematical Statistics. Wiley Eastem Ltd. New Delhi. Student Edition.
3. Dudewicz E.J. & Mishra S. N. (1988) : Modern Mathematical Statistics. Wiley Seris in Prob., Stat. John. Wiley & Sons. New York. International students edition.
4. Lehman E. L. (1987) : Theory of testing of hypotheses. Students Edition.
5. Ferguson T.S. (1967) : mathematical Statistics. A decision theoretical approach. Academic press.
6. Zacks S. ( 1971) : Theory of Statistical Inference John Wiley and Sons. New York.


## MCST 203 : MULTIVARIATE ANALYSIS

Unit-1: Multivariate normal distribution, two definitions and their equivalence , singular and nonsingular normal distribution, characteristic function, moments, marginal and conditional distributions.

(9)

Unit-2: Maximum likelihood estimators of the parameters of the multivariate normal distribution and their sampling distributions.

(5)

Unit-3: Wishart matrix and its distribution ,properties of Wishart distribution, distribution of generalized variance.

(6)

Unit-4: Hotelling's $T^2$ Statistic and its distribution. Applications of $T^2$ statistic and its relationship with Mahalanobis' $D^2$ statistic. Confidence region for the mean vector.

(6)

Unit-5: Discrimination and classification. Fisher's discriminant function and likelihood ratio procedure, minimum Expeceted Cost of Mis-classification (ECM) rule,

Rao's U statistics and its use in tests associated with discriminant function, classification with three populations.

(6)

Unit-6: Principal components. Dimension reductions, Canonical Correlation and canonical variables.

(5)

Unit-7 : Introduction to factor analysis, Cluster analysis, Heirarchical and non-Heirarchical clustering. Single, Complete, average linkage method and K-means clustering.

(8)

Reference:-


1. Kshirsagar A. M.(1972) : Multivariate Analysis. Maral-Dekker.
2. Johnosn, R.A. and Wichern . D.W (2002) : Applied multivariate Analysis. 5th Ad. Prentice –Hall.
3. Anderson T. W. (1984) : An introduction to Multivariate statistical Analysis 2nd Ed. John Wiely.
4. Morrison D.F. (1976) : Multivariate Statistical Methods McGraw-Hill.


## MCST 204 : LINEAR MODELS AND DESIGN OF EXPERIMENTS

1. General linear model: definition, assumptions, concept of estimability, least squares estimation, BLUE, error space, estimation space, Guass Markov theorem, variances and covariances of BLUEs.

(8)

2. Distribution of quadratic forms for normal variables: related theorems (without proof). Tests of hypothesis in general linear models.

(4)

3. Analysis of variance : one way classification, two way classification without interaction and with interaction with equal number of observations per cell. Estimation and related tests of hypothesis, Tukey's test of additivity. (8)

4. Multiple comparisons: Three types of errors, Tukey , Sheffe and Bonferroni producer. (3)

5. Analysis of Covariance: estimation of parameters, related tests of hypothesis. General theory and application of one way and two way set up.

(6)

6.General block design : Two way classification with unequal number of observations per cell (without interaction), connectedness, balancedness , orthogonality, related tests of hypothesis.

(9)

7. BIBD : Definition, parametric relationship, Inter and Intra Block analysis, Symmetric BIBD.

(7)

References:


1. Kshirsagar A. M.(1983) : Course in Linear Models - Marcel dekker.
2. Joshi D. D.(1987) : Linear Estimation and Analysis of Experiments - Wiley Estern Ltd.
3. Giri N. S. & Das M. N.(1979) : Design and Analysis of Experiments - Wiley Estern Ltd.
4. Searle S. R. (1971): Linear Models - John Wiley & Sons. New York.
5. Chakravarti . M. C.( 1962) : Mathematics of Design of Experiments - Asia Publishing House , Bombay.


## MCST 205: SAMPLING THEORY

1. Concept of population and sample, Need for Sampling, census & sample surveys, basic concepts in sampling and designing of large-scale surveys design, sampling scheme and sampling strategy. Basic methods of sample selection: SRSWR, SRSWOR. (6)
2. Stratification, Allocation and estimation problems. Construction of Strata: deep stratification, method of collapsed strata. (6)
3. Systematic sampling: The sample mean and its variance, comparison of systematic with random sampling, comparison of systematic sampling with stratified sampling, comparison of systematic with simple and stratified random sampling for certain specified population. Estimation of variance, (6)
4. Two stage sample: Equal first stage units, Two stage sample: Unequal first stage units; systematic sampling of second stage units. (3)
5. Cluster sampling. Two – stage sampling with equal number of second stage units. (5)
6. PPSWR methods: Cumulative total method, Lahiri's method related estimation Problems and PPSWOR methods and related estimation of a finite population mean (Horwitz- Thompson and Des Raj estimators for a general sample size and Murthy's estimator for a sample of size 2), Midzuno sampling. (8)
7. Use of supplementary information for estimation: ratio and regression estimators and their properties. Unbiased and almost unbiased ratio type estimators, Double sampling. (6)
8. Non - sampling errors: Response and non- response errors. Hansen – Horwitz technique (4)

**References**

1. Sukhatme P. V., Sukhatme S. & Ashok C : Sampling Theory of surveys and applications – Piyush publications
2. Des Raj and Chandhok. P. (1998) : Sample Survey Theory - Narosa publication.
3. William G. Cochran. ( 1977) : Sampling Techniques- III$^{rd}$ edition –John and Wieley sons Inc.
4. Parimal Mukhopadhyay (1998) : Theory and methods of survey sampling -Prentice Hall of India private limited.
5. Murthy M.N. (1977) : Sampling Theory of Methods - Statistical Publishing Society, Calcutta.

## MST 216- PRACTICAL –II

1. Sampling from multivariate distribution.
2. Multiple and partial correlation.
3. Application of Hotelling's $T^2$ statistics.
4. Discriminant Analysis-I
5. Discriminant Analysis-II
6. Canonical correlation and variance.
7. Principle component analysis.
8. Factor Analysis.
9. Cluster Analysis
10. M.P. Tests
11. UMP Tests
12. UMPU Tests.
13. Likelihood ratio tests.
14. Confidence Intervals.
15. Non-parametric Tests-I.
16. Non-parametric Tests-II.
17. Linear Estimation: Estimation and Hypothesis testing-I.
18. Linear Estimation: Estimation and Hypothesis testing-II.
19. ANOVA : One way and two way orthogonal data without interaction.
20. ANOVA: Two way orthogonal data with interaction
21. Two way non-orthogonal data without interaction
22. Analysis of BIBD.
23. Analysis of general block design.
24. Stratified and Systematic Sampling .
25. Cluster and two stage Sampling.
26. PPS Sampling.(Horvitz-Thompson and Murthy estimator)
27. Ratio Method of estimation.
28. Regression Method of estimation.