Syllabi of M.A./M.Sc. in Statistics (Choice based Credit System)

(To be implemented in the affiliated Colleges of , University of Pune from July 2013)

1) **Title of the Program:** M. A. / M. Sc. in Statistics

2) **Preamble to the syllabus:** M. A. / M. Sc. Statistics program is of minimum 100 credits spread over four semesters. This program is offered at the colleges affiliated to the University of Pune. The programme emphasizes both theory and applications of statistics and is structured to provide knowledge and skills in depth necessary for the employability of students in industry, other organizations, as well as in academics. Accordingly, the programme has important features such as individual/ group projects, elective courses and courses on standard software packages such as MATLAB, MINITAB, SYSTAT, SPSS , R. Syllabus of the first two semesters covers core courses. The second year syllabus contains both core, elective and open courses. It is possible for the students to study basic courses from other disciplines such as economics, life sciences, computer science, mathematics in place of electives.

3) **Introduction:**

(a) M. A./ M. Sc. Statistics programme will be conducted under credit system in four semesters. There will be approximately 25 credits in each semester for a total of 100 credits. Each course is given credit values between 1 and 4 depending on the expected study load of the student. One credit is taken to be equivalent to 15 clock hours of study load.

(b).The programme consists of core courses which may be hard-core (compulsory) or soft-core (Elective).

(c)Some courses are termed Open Courses (O). The open courses are those offered by other departments but relevant to M. A./M. Sc. Statistics programme.

(d).In addition, there are Laboratory courses and Project courses.

(e).For every course, there will be Continuous Internal Assessment (CIA) conducted by department or college and End of the Semester Examination (ESE) will be conducted by the University at the end of semester.

4) Eligibility : For M.A./ M.Sc. in Statistics following candidates are eligible.

Bachelor of Arts / Science with Statistics as a Special / Principal subject.

5. Examination:

A) (i) **Pattern of examination**: There would be Continuous Internal Assessment (CIA) or in semester assessment and an End of Semester Examination (ESE) for each course. CIA includes written examinations, assignments, small projects, viva- voce examinations , presentations seminars, quizzes etc.

(ii) **Pattern of the question paper at End of Semester Examination (ESE)**: Duration of ESE will be 45 minutes per credit each of 20 marks.

B) Standard of passing:

i) For passing the course, student has to score at least 40% marks in ESE and CIA combined .Moreover student has to score minimum 30% marks in CIA as well as in ESE separately.

(ii)The grade for the course is declared on the basis of combined marks in CIA and ESE with a weightage of 50% marks in CIA and 50% marks in ESE.

(iii) If student fails in the course, he has to reappear for ESE. However his performance in CIA will be carried forward.

C) ATKT rules: i) A student can take admission to the third semester, if she/he completes 50% credits of the total credits expected to be completed within first two semesters.

ii) If a student fails in a course, he/ she can reappear for the CIA by registering for the said courses during 5^{th} , 6^{th} , 7^{th} or 8^{th} semester. Otherwise the existing performance at CIA will be carried forward.

D) Award of class: As per the University rules.

E) External students: Not applicable

F) Setting of question paper: As per the University rules

G) Verification or revaluation and photo copy of answer book: As per the University rules.

H) Grade Improvement: For grade improvement minimum 30 credit courses should be taken by the student from parent department. Grade Improvement Program will be implemented at the end of the academic year. A student can opt for the grade improvement program only after declaration of result of final semester examination(i.e. at the end of the next academic year after passing the M.A./ M. Sc. Examination) within two years of completion of M.A./ M. Sc. and only once.

6. Structure of the program:

T: Theory P: Practical O: Open C: Compulsory E: Elective

Semester I

Course Code	T/ P	O/C/ E	Title	No. of credits	ESE Duration	Marks Assigned
ST - 11	**T**	**C**	Mathematical Analysis	**4**	3 Hours	80
ST - 12	**T**	**C**	Integral Calculus and statistical computing	**2**	1Hour 30 minutes	40
ST - 13	**T**	**C**	Linear Algebra	**4**	3 Hours	80
ST - 14	**T**	**C**	Probability Distribution I	**2**	1Hour 30 minutes	40
ST - 15	**T**	**C**	Probability Distribution II	**3**	2Hours 15 minutes	60
ST - 16	**T**	**C**	Sampling Theory	**4**	3 Hours	80
ST - 17	**P**	**C**	Practicals -I	**4**	3 Hours	80
ST - 18	**P**	**C**	Practicals -II	**2**	1Hour 30 minutes	40
			Total	**25**		500
Semester II						
ST - 21	**T**	**C**	Probability Theory	**3**	2Hours 15 minutes	60
ST - 22	**T**	**C**	Limit theorems and Convergences	**3**	2Hours 15 minutes	60
ST - 23	**T**	**C**	Regression Analysis	**4**	3 Hours	80
ST - 24	**T**	**C**	Parametric Inference (Estimation)	**4**	3 Hours	80
***ST - 25**	**T**	**C**	Testing of hypothesis	**1**	2Hours 15 minutes	20
***ST - 26**	**T**	**C**	Exploratory Multivariate Analysis *** ESE for ST 25 and ST 26 will be held together.**	**2**		40
ST - 27	**T**	**C**	Inference in Multivariate Analysis	**3**	2Hours 15 minutes	60
ST - 28	**P**	**C**	Practicals III	**4**	3 Hours	80
			Total	**24**		480

Tentative structure for Semester III and IV is as follows ,the details will be given latter on.

Semester III

ST 31 (TC) Elementary Stochastic Processes : 4 credits

ST 32 (TC) Design of Experiments : 4 credits

ST 33 (TC) Asymptotic Inference : 4credits

ST 34 (TE) Elective Course I : 4Credits

ST 35 (TE) Elective Course II : 4Credits

ST 36 (PC) Practicals III : 3 Credits

ST 37 (PC) Practicals IV : 2 Credits

Semester IV

ST 41 (TC) Survival Analysis: 4 credits

ST 42 (TC) Statistical Process Control : 3 credits

ST 43 (TC) Non Parametric Inference : 2 credits

ST 44 (TC) Time Series Analysis : 4 credits

ST 45 (TE) Elective Course I : 4 credits

ST 46 (TE) Elective Course II : 4 credits

ST 47 (PC) Practicals V : 2 credits

ST 48 (PC) Project : 3 credits.

Elective Courses (ST 34 and ST 35)

E 1. Clinical Trials : 4 credits

E2. Data mining : 4 credits

E 3.Measure theory and Advanced probability : 4 credits

E 4. Advanced Inference : 4 credits

E5. Baysian inference : 4+4 credits

E 6. Statistical Education : 3 credits

E7. Analysis of directional Data : 2 credits

E8. SAS programming. : 2credits

Elective Courses : (ST 45 and ST 46)

E1. Advanced stochastic process : 4 credits

E2. Actuarial Statistics : 4 credits

E3. Optimization techniques : 3 credits

E4.Discrete event simulation : 3 credits

E5. Demography : 2 credits

E6. Research methodology : 2 credits

E7. Statistical Education : 2 credits

E 8. Economics : 4 credits.

E9. C++ programming : 2 credits

Note: Board of studies in statistics has discretion to update list of courses and syllabi.

7. Notes for implementation of the program

a. Number of lectures per credit is 15 , (13 Theory + 2 for Tutorials, seminars, tests etc.)

b. Each credit of practical course will be allotted 1hour 30 minutes laboratory work per week.

c. Nature of CIA of practical course :

i) Journal day to day completion 25 % marks.

ii) Viva – voce day to day experiments. 25% marks.

iii) Internal tests 50% marks.

d. Nature of ESE of practical course : ESE will be of 45 minutes duration per credit having 20 marks per credit of which 10% marks will be reserved of viva –voce at the time of examination

e. There should not be more than 10 students in a batch for M.Sc. practical course.

f. At least two interactive sessions per course per semester be conducted by concerned teachers.

g. In order to acquaint the students with applications of statistical methods in various fields such as industries, agricultural sectors, government institutes etc. study tour be arranged.

ST- 11 (TC):Mathematical Analysis (from2013-14) 4 credits

Unit 1:

Set of real numbers, supremum and infimum of sets of real numbers, real field, existence theorem of ordered field R (with proof). countable and uncountable sets, countability of rational and unaccountability of the real numbers, Metric Spaces, Interior point, Exterior point, Boundary point, limit point of a set, open set, closed set, and compact sets. Bolzano-Weierstrass and Heine-Borel Theorem (with proof). Applications of these theorems.

[15L]

Unit 2:

Sequences of real numbers, convergence and divergence of sequences and subsequences,Cauchy sequence, Limit inferior, limit superior of the sequences, some special sequences.

[15L]

Unit 3:

Series of real numbers, series of non negative terms, convergence of series, tests of convergence of series (root test, ratio test with proof) absolute convergence, Power series and applications to power series, addition and multiplication of the series, radius of convergence of Binomial, exponential, geometric and log series. Differentiation and integration of power series.

[15 L]

Unit 4:

The derivative of a real function, mean value theorem, the continuity of derivatives, L'Hospital's Rule, Taylor's Theorem. Cauchy- Schwartz inequality, fundamental theorem of a calculus, integration by parts, differentiation under the sign of integral.

[15 L]

Books Recommended:

1. Rudin W.(1985), Principles of Mathematical Analysis (McGraw – Hill)
2. Apostol T. M. (1975) Mathematical Analysis: A Modern Approach to Advanced Calculus. (Addison - Wesley)
3. Bartle R. G. (1976), Elements of Real Analysis (Wiley)
4. Malik S. C. & Arora S. (1991), Mathematical Analysis (Wiley Eastern Limited 2nd edition)
5. Goldberg R. R. (1964) : Methods of Real Analysis- Blaisdell Publishing company, New york, U.S.A.
6. Bartle G.R. & Sherbert D. R. (2000): Introduction to Real Analysis- John Wiley & Son Inc.
7. Royden (1988), Principles of Real Analysis (Macmillian)
8. Trench : ( ) Real Analysis

ST- 12(TC): Integral Calculus and Statistical computing (from2013-14) 2 credits

Unit 1: Riemann and Riemann- Stieltjes Integral, applications in Statistics,

[10 L]

Unit2:Improper integrals of first and second kind for one variable, conditions for convergenceof beta and Gamma functions , relation between beta and gamma functions, properties of beta and gamma functions, duplication formula. Implict function Theorem / Inverse function theorem and their simple applications. **[5 L]**

Unit 3 : (i)Newton–Raphson method for two or more simultaneous transcendental equations,

(ii) Newton's bivariate interpolation formula,

(iii) Unconstrained optimization : Grid search method, Gradient search : Seepest descent method ,Newton's , method.

(iv) Simpson's , Trapezoidal rule for bivariate integrals;

(v) Simulation : Linear congruential generator ; Monte Carlo method to evaluate single and multiple integrals.

(vi) Jack – Knife estimators.

(vii) Boot-Strap method **[15 L]**

Books Recommended:

1. Rudin W.(1985), Principles of Mathematical Analysis (McGraw – Hill)
2. Apostol T. M. (1975) Mathematical Analysis: A Modern Approach toAdvanced Calculus. (Addison - Wesley)
3. Bartle R. G. (1976), Elements of Real Analysis (Wiley)
4. Malik S. C. & Arora S. (1991), Mathematical Analysis (Wiley Eastern Limited2nd edition)
5. Goldberg R. R. (1964) : Methods of Real Analysis- Blaisdell Publishing company, New york, U.S.A.
6. Bartle G.R. & Sherbert D. R. (2000): Introduction to Real Analysis- John Wiley & Son Inc.
7. Royden (1988), Principles of Real Analysis (Macmillian)
8. Trench W. F. (2012). Introduction to Real Analysis. E-book.
9. V. Rajaraman (1993): Computer Oriented numerical methods. Prentice Hall
10. Krishnamurthy and Sen: Numerical Algorithms(East West press Pvt. Ltd.)
11. S.S. Sastry (4^{th} edition ,2009)Prentice Hall : Introductory methods of Numerical Analysis.

ST- 13 (TC)Linear Algebra (From 2013-14) 4 credits

Unit 1: Vector space, subspace, linear dependence and independence, basis of vector space, dimension of a vector space, orthogonal and orthonormal vectors, orthonormal basis, Gram- Schmidt orthogonalization Matrix algebra, special types of matrices, orthogonal matrix, idempotent matrix partitioned matrices, elementary operations, rank of a matrix, inverse of a matrix

[15L]

Unit2: Characteristic roots of a matrix, right and left characteristic vectors,

Properties of characteristic roots and vectors, algebraic and geometric multiplicities, spectral decomposition, n^{th} power of a matrix, Cayley- Hamilton theorem.

[15L]

Unit 3: g-inverse, Moore-Penrose g-inverse, solution of a system of homogeneous and non- homogeneous linear equations. Gauss seidal and Gauss Jacobbi iterative methods.

[15L]

Unit 4: Quadratic forms, definition, reduction and classification, simultaneous reduction of two quadratic forms, maxima and minima of ratio of quadratic forms.

[15L]

Books:

(1) Searle S.A.(1982): Matrix Algebra Useful for Statistics, Wiley

(2) Graybill (1961): An introduction to linear Statistical models Volume I, Mc Graw Hill

(3) Rao C.R. (1973) :Linear Statistical Inference and its Applications, Wiley Eastern

(4) Hadley G. (1987) :Linear Algebra, Narosa

(5) Rao, C.R. and Bhimashankaram, P. (1992) :Linear Algebra,Tata Mc Graw Hill

Additional Reference : http// aix1.uottawa.ca/~ jkhoury/app.htm

ST 14 : (TC) Probability Distributions I (From 2013-14) 2 crdits

Unit 1: Brief review of a random variable, c.d.f and its characteristic properties with proof for univariate and bivariate probability distributions, quantiles, discrete, continuous distributions, p.m.f., p.d.f., symmetric distributions, mixtures of probability distributions, transformation of random variables, m.g.f, moments, p.g.f , compound distribution.

[15L]

Unit 2: Random vectors, joint probability distributions, joint m.g.f., mixed moments, variance covariance matrix, independence, sums of independent r.v.s , convolutions, conditional expectation and variance, regression function and best linear regression function, multiple and partial correlation coefficient

[15L]

1. Rohatagi V.K. & Saleh A.K.(2001) Introduction to probability theory and mathematical statistics. (John Wiley and sons)
2. Johnson N.L. & Kotz S.(1996) Distributions in statistics Vol.I .VolI and Vol III John Wiley and sons Inc.)
3. Johnson N.L., Kotz S., Balkrishnan, N. Multivariate Distributions (John Wiley and sons)
4. Casella and Burger(2002) Statistical Inference (Duxbury advanced series II edition)
5. Hogg RV and Craig T T (1978) Introduction to mathematical Statistics 4thedn. (Collier McMillan)
6. BLS Prakash Rao ; First course in probability

ST 15 (TC): Probability Distributions II(From 2013-14) 3 crdits

Unit 1: Bivariate Poisson, bivariate exponential (all 4 types), bivariate normal distribution, Dirichilet distribution and their properties

[15L]

Unit 2 : a)Exponential family of distributions, location and scale families, non-regular families

[7L]

b) Review of order statistics, joint distribution of all order of statistics, probability integral transformation,distribution of rank factors, distributions of sign statistic, Kolmogorov-Smirnov statistic and Wilcoxon sign rank statistic

[8L]

Unit 3: Sampling distributions of quadratic forms and linear forms for random samples from normal distribution, Fisher Cochran theorem, Non-central chi-square, t, F distribution [15L]

Books :

1. Rohatagi V.K. & Saleh A.K.(2001) Introduction to probability theory and mathematical statistics. (John Wiley and sons)
2. Johnson N.L. & Kotz S.(1996) Distributions in statistics Vol.I .VolI and Vol III (John Wiley and sons Inc.)
3. Johnson N.L., Kotz S., Balkrishnan, N. Multivariate Distributions (John Wiley and sons)
4. Casella and Burger(2002) Statistical Inference (Duxbury advanced series II edition)
5. Hogg RV and Craig T T (1978) Introduction to mathematical Statistics 4th edn. (Collier McMillan)
6. BLS Prakash Rao ; First course in probability

ST-16: (TC)Sampling Theory (From 2013-14) 4 crdits

Unit 1: Basic finite population techniques SRSWR, SRSWOR Inclusion probabilities, related results on estimation of population total, Determination of sample size in various aspects. 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.

[15L]

Unit 2: Horwitz – Thompson estimator, its variance and properties, midzuno scheme of sampling. Stratified sampling, comparison of allocation problem of allocation in stratified sampling, construction of strata, deep stratification.

[15L]

Unit 3: Use of supplementary information for estimation, ratio and regression estimators using separate strata and combined strata, unbiased and almost unbiased ratio type estimators of population mean post stratification, variance of estimator of population mean under it.

Systematic sampling, sample mean and its variance, circular systematic sampling, two dimensional systematic sampling , comparison of systematic sampling with random sampling and stratified sampling with random sampling and stratified sampling.

[15L]

Unit 4 : Cluster sampling with cluster sampling with clusters of equal sizes and unequal sizes , estimation of population mean and its standard error, two stage sampling with equal first stage units, expected value and the variance of sample mean. Sampling and non – sampling errors, Response errors, mathematical model for Response errors, Hansen Horwitz technique, Randomized Response Technique (RRT). Warner's randomized response technique. **[15L]**

Books:

(1) Sukhatme P.V. Sukhatme B.V. and C. Ashok Sampling theory of survey and applications (Indian society for Agricultural statistics)

(2) Des Raj & Chandhok P.(1998), Sample survey theory (Narosa)

(3) W. G. Cochran ,(1977) Sampling techniques (John Wiley and sons)

(4) Murthy M.N.(1977) Sampling theory and methods (Statistical Publishing Society)

ST-17(PC) Practical s - I (From 2013-14) 4 credits (6 hours a week)

1. Introduction to Statistical Software-I
2. Introduction to Statistical Software-II
3. Matrices
   Contents: Properties of Matrices, Inverse of matrix and non – singular matrix, inverse by partitioning..
4. G-Inverse
5. MPG-Inverse
6. Eigen Value, eigen Vectors, Spectral Decomposition, Power of matrix.
7. Solution of System of Linear Equations using Gauss elimination , Gauss Jorden, Gauss Seidal and Gauss Jacobbi metods .
8. Classification and Reduction of Quadratic forms.
9. Plotting of density function and distribution functions.
10. Model sampling from Gamma , Chi-square ,Weibull ,lognormal probability distribution.
11. Model sampling from mixture of distribution
12. Model sampling from bivariate probability distribution
13. Computation of probability of events related to bivariate probability distributionComputation of probability of non-central χ^2, t, F-distributions
14. PPS sampling
15. Stratified sampling(using Ratio and Regression) , Ratio and Regression estimates
16. Circular Systematic Sampling
17. Cluster Sampling with equal cluster size
18. Cluster Sampling with unequal cluster size
19. Two stage sampling

ST-18(PC) Practical s II(From 2013-14) 2 credits (3 hours a week)

1. Computations of Summary Statistics using R.
2. Model sampling from density function and distribution function using R.
3. Simultaneous Transcendental equations N- R method.
4. Grid search , steepest descent and Newton's Method of optimization.
5. Bivariate interpolation.
6. Computations of double integral
7. Numerical integration using simulations.
8. Computation of integral by Riemann and Riemenn – Stiltjes sums.
9. Boots Trap method
10. Jack knife method

ST 21 : (TC) Probability Theory (From 2013-14) 3 credits

Unit 1: Review of algebra of sets, sequence of sets , limsup, liminf and limit of a sequence of sets, field, sigma field, minimal sigma field, Borel fields, measurable space , monotone classes. Probability measure on a measurable space, probability space, properties of probability measure: continuity, mixture of probability measures, Lebesgue and Lebesgue-Steltjes measures.

[**15L]**

Unit 2: Measurable function, Real and Vector valued random variables, simple r.v., r.v. as a limit of sequence of simple r.v.s, discrete and continuous type r.v., distribution function, decomposition of a distribution function

[15L]

Unit 3: Integration of a measurable function with respect to a probability measure, expectation of a r.v., properties of expectation, characteristic function and properties, Parseval relation, uniqueness theorem, inequalities of moments

[15L]

Books :

(1) Bhat B.R.(1985) Modern Probability theory (Wiley Eastern)

(2) Breiman : Probability Theory

(3) Billingsley P. (1986) Probability and Measure (Wiley)

(4) Feller W. (1969) Introduction to probability and its applications Vol I and Vol.II (Wiley Eastern)

(5) K. L. Chung ( ):Probability Theory.

ST 22 (TC) : Limit theorems and Convergence s : 3 Credits

Unit 1: Convergence of a sequence of r.v.s,

- **a)** convergence in probability
- **b)** convergence in distribution
- **c)** convergence in r^{th} mean ,
- **d)** almost sure convergence, their inter-relations
  Slutkey's Theorem

[15L]

Unit 2: Independence of two and n (>2) events, sequence of independent events, π and λ systems, Dynkin's theorem (Introduction) independence of r.v.s ,Kolmogorov, zero-one law, Borel Cantelli lemma

(15L)

Unit 3: Law of Large Numbers : Weak Law of Large Numbers (WLLN),
Khintchin's WLLN, Strong Law of Large Numbers (SLLN)
(Statement only), Central Limit Theorem (CLT)
Levy continuity theorem, CLT for i.i.d. r.v.s, Liaponove's form,
Lindeberg Feller form and their applications

(15L)

Books :

(1) Bhat B.R.(1985) Modern Probability theory (Wiley Eastern)
(2) Breiman : Probability Theory
(3) Billingsley P. (1986) Probability and Measure (Wiley)
(4) Feller W. (1969) Introduction to probability and its applications Vol I and Vol.II (Wiley Eastern)
(5) K. L. Chung: Probability theory.

ST-23 : (TC) Regression Analysis (From 2013-14) 4credits

Unit 1 Simple linear regression, assumptions, least square (LS) estimators of parameters, standard error . of estimators, testing of hypothesis for coefficient of regression, s.e. of prediction, testing of hypotheses about parallelism (Slopes) ,equality of intercepts, congruence, extrapolation, optimal choice of independent variables, , diagnostic checks and correction: graphical technique, tests for normality , uncorrelated ness, homo scadasticity, lack of fit. modifications like polynomial regression, transformations on of dependent or independent variables , weighted LS, inverse regression.

[15L]

Unit 2 Multiple regression: Standard Gauss-Markov setup, least square estimation, error and estimation spaces, variance and covariance of LS estimators, properties of LS estimators, estimation of error variance, case with correlated observation, LS estimation with restriction on parameters, simultaneous estimation of linear parametric functions, testing of hypothesis for one and more than one linear parametric functions, confidence intervals and regions.Mallows Cp, forward, backward selection method.

[15L]

Unit 3: a) Multicollinearity : consequences, detection and remedies, autocorrelation consequences, Durbin Watson test, estimation of parameters in autocorrelation. [4L]

b) Multiple correlation, adjusted multiple correlation coefficient, null distribution of simple correlation and multiple correlation coefficient, partial correlation coefficient and its relation with multiple correlation coefficient, test for significance of simple ,multiple and partial correlation coefficients, variable selection procedures.

Residual and residual diagnostics, transformation of variables: Box-Cox power Transformation, generalized weighted least sequence.

[11L]

Unit 4: a) Non-linear regression: Non-linear least squares transformation to a linear model, statistical inference in non-linear regression

[5L]

b) Logistic regression: Logit transform, ML estimation, tests of hypothesis, Wald test, LR test, score test, test for overall regression, introduction to link functions such as binomial, inverse binomial, inverse Gaussian and Gamma. [7L]

c) Generalized linear model : [3L]

Books:

(1) Draper, N. R. and Smith H. (1998) Applied regression analysis 3rd edition (John Wiley)

(2) McCullagh, P. and Nelder, J. A.(1989) Generalized linear models (Chapman and Hall)

(3) Ratkowsky, D. A.(1983) Nonlinear regression modeling (Marcel Dekker)

(4) Hosmer, D. W. and Lemeshow, S. (1989) Applied logistic regression (John Wiley)

(5) Neter, J.; Wasserman, W. and Kutner, M.H.(1985) Applied linear statistical models

(6) Montogomery D.C. et. al.(2003) Introduction to linear regression analysis (Wiley Eastern)

ST 24: (TC) Parametric Inference Estimation (From 2013-14) 4credits

Unit 1: Sufficiency :- Factorization theorem, joint sufficiency , likelihood equivalence , minimal sufficiency, construction of minimal sufficient statistics, Special classes of distribution, admitting minimal sufficient statistics.

[15L]

Unit 2: Fisher information & information matrix Completeness, bounded completeness, complete sufficient statistics, special classes of distribution admitting complete sufficient statistics.

[15L]

Unit 3:- Complete minimal sufficient statistics, ancillary statistics, Basu's theorem & its application unbiased estimator, UMVUE, n & s condition for existence of UMVUE (with proof), Rao-Blackwell theorem, Lehman- scheffe theorem, & there uses, C-R inequality, Regularity conditions , MVBUE , Chapman robin's bound, Bhattacharya bound (withproof).

[15L]

Unit 4:- Confidence interval, relation with testing of hypothesis , SELCI, UMACI. introduction to Bayesian estimation, prior & posterior distribution, loss function, principle of minimum expected posterior loss, quadratic & other common loss functions, conjugate family of prior distribution & its examples.

[15L]

Books:

1. Kale B.K. (1999) A First course on Parametric Inference (Narosa)
2. Casella G. & Beregar R.L. (2002) Statistical Inference, 2nd Edition (Duxbury Advanced Series)
3. Dudewitz E.J. & Mishra S.N.(1988) Modern Mathematical Statistics (John Wiley)
4. Lehman E.L (1988) Theory of point estimation (John Wiley)
5. Lehman E.L(1986) Testing of Statistical hypotheses (John Wiley)
6. Rohatagi V.K. (1976) Introduction to theory of probability & mathematical statistics (John Wiley & sons)

ST 25 : (TC) Testing of Hypothesis (From 2013-14) 1 credits

Unit 1:- Test function, NP lemma (with proof) for test function, UMP test for one-sided alternative for one parameter, exponential class of densities & extension to the distributions having MLR property. UMPU test.

[15L]

Books:

1. Kale B.K. (1999) A First course on Parametric Inference (Narosa)
2. Casella G. & Beregar R.L. (2002) Statistical Inference, 2nd Edition (Duxbury Advanced Series)
3. Dudewitz E.J. & Mishra S.N.(1988) Modern Mathematical Statistics (John Wiley)
4. Lehman E.L (1988) Theory of point estimation (John Wiley)
5. Lehman E.L(1986) Testing of Statistical hypotheses (John Wiley)
6. Rohatagi V.K. (1976) Introduction to theory of probability & mathematical statistics (John Wiley & sons)

ST-26 : (TC) Exploratory Multivariate Data Analysis (From 2013-14) 2credits

Unit 1 a) Exploratory Multivaritate Data Analysis: Sample mean vector, dispersion matrix, Correlation matrix.

Linear Transformation and its Mean, Variance. Covariances, Correlation between linear transformations. Graphical representation.

b) Cluster analysis

(15L)

Unit 2. Principal component analysis, Factor analysis, Canonical correlation, with applications.

(15L)

Books:

1. Anderson T.W.(1984) Introduction to multivariate analysis (John Wiley)
2. Kshirsagar A.M. (1983) Multivariate Analysis(Marcel Dekker.)
3. C.R.Rao (1985 Linear Statistical inference and its applications (Wiley Eastern Ltd)
4. Johnson R.A. and Wichern D.W.(1988)Applied multivariate statistical analysis (Prentice hall Inc.)
5. K.C. Bhuyan (2005) Multivariate Analysis and its application, New Central book agency, LTD. Kolkatta
6. Morrison, D.F.(1990). Multivariate Statistical Methods (McGraw Hill Co.) (3rd ed.)
7. Johnson R.A. & Wichern, D.W. (1988). Applied Multivariate Statistical analysis (Prentice Hall Inc.)
8. Hardle, W. K. & Simar, L. (2012) , Applied Multivariate Statistical analysis (Springer, New York)

ST-27 : <u>Inference in Multivariate analysis (TC) 3 credits</u>

Unit 1. Multivariate normal distribution, singular and non -singular normal distributions, m.g.f., Characteristic function, moments, distribution of a linear form and a quadratic form of normal variables, Marginal and conditional distribution. Tests for multivariate normality, Test of significance for multiple and partial correlation coefficients.

(15L)

Unit 2. M.L.E.S. of parameters of multivariate normal distribution and their sampling distribution. Wishart matrix, Wishart distribution and its properties. Tests of hypothesis about mean vector of a multivariate normal population. Hotelling T^2 statistic and its distribution, its applications. confidence region for mean vector of multivariate normal Distribution.

(15L)

Unit 3. Likelihood ratio test. Test for equality of dispersion matrices , Discriminant analysis, Mahalanobis D^2 Statistic, test for significance of the coefficients in discriminant function. Misclassification error.

(15L)

Books:

5. Anderson T.W.(1984) Introduction to multivariate analysis (John Wiley)

6. Kshirsagar A.M. (1983) Multivariate Analysis(Marcel Dekker.)

7. C.R.Rao (1985 Linear Statistical inference and its applications (Wiley Eastern Ltd)
8. Johnson R.A. and Wichern D.W.(1988)Applied multivariate statistical analysis (Prentice hall Inc.)
8. K.C. Bhuyan (2005) Multivariate Analysis and its application, New Central book agency, LTD. Kolkatta
9. Morrison, D.F.(1990). Multivariate Statistical Methods (McGraw Hill Co.) (3rd ed.)
10. Johnson R.A. & Wichern, D.W. (1988). Applied Multivariate Statistical analysis (Prentice Hall Inc.)

8. Hardle, W. K. & Simar, L. (2012) , Applied Multivariate Statistical analysis (Springer, New Yorek)

ST 28: PRACTICAL PAPER III (Departmental Course) 4 credits

1 Simple regression and regression diagnostic I
2 Multiple regression
3 Lack of fit of the regression model
4 Multiple regression (selection of variable)
5 Nonlinear regression model
6 Multicollinearity and orthogonal polynomial regression.
7 Logistic regression I
8 Generalized Linear Model and Poisson regression.
9 Application of Central Limit Theorem and weak law of large number
10 Exploratory multivariate data analysis.
11 Multivariate analysis (contour plot).
12 Principal component analysis .
13 Factor Analysis.
14 Cluster Analysis.
15 Canonical correlation.
16 Model sampling from multivariate normal distribution. And computation of M.L.E.'s of parameters.
17 Likelihood ratio test.
18 Application of Hotelling T^2 statistics.
19 Discriminant analysis