University of Pune

Two Year M. A. / M. Sc. Degree Program in Statistics

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

(To be implemented in the colleges affiliated to University of Pune)

(With effect from Academic Year 2013-2014)

Submitted by

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Chairperson,
Board of Studies in Statistics

1.	**Title of the Programme:**	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 program me 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, R. Syllabus of the first two semesters covers core courses. The second year syllabus contains both core and elective 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:**	
	1. 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 2 and 6 depending on the expected study load of the student. One credit is taken to be equivalent to 12 clock hours of study load. 2. The programme consists of core courses which may be hard-core (compulsory) or soft-core (Elective). 3. 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. 4. In addition, there are Lab courses and Project courses. 5. A course may be Departmental Course (D) for which entire evaluation is conducted by the department or college. Otherwise the course is called a University Course (U). For an U course, there will be Continuous Internal Assessment (CIA) conducted by department or college and University Examination (ETE) at the end of term conducted by the University.	
4.	**Eligibility:**	
	For M. A./ M. Sc. in Statistics following candidates are eligible. B.A./B.Sc. with Statistics at principal level and Mathematics at subsidiary level	
5.	**Examination:**	
	A) (i) Pattern of examination: There would be continuous internal assessment (CIA) and an end of term examination (ETE) for each course. CIA may be in the form of written tests, home/class assignments, small projects, presentations, seminars, quizzes, viva-voce, and any other. However, there should be at least three evaluations, one of which must be a written examination. **(ii) Pattern of the question paper at End of Term Examination (ETE)**: (a) For a course with **one credit,** duration of the examination is one hour. Students have to attempt two questions out of three. (b) For a course with **two or three credits**, duration of the examination is two hours and students have to attempt three questions out of four. (c) For a course with **four, five or six credits**, duration of the examination is three hours	

and students have to attempt five questions out of eight.

B) Standard of passing: The grade for a course is computed on the basis of combined marks in ETE and CIA with a weightage of 75% to ETE and 25% to CIA. In order to pass in a course, a student must obtain a minimum 40% marks both at ETE and in aggregate of CIA and ETE.

C) ATKT rules:
(i) A student can take admission to the third semester, if s/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 if the college makes a provision; otherwise the existing performance at CIA will be carried forward. In any case, he/she has to appear for ETE whenever University conducts such examination for the course to pass in the course.

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, revaluation and photo copy of answer book: As per the University rules.

6. (a,b) **Structure of the M.A./M.Sc. Statistics Programme:** In the following,

T: Theory **P:** Practical **U:** University **D:** Departmental
O: Open **C:** Compulsory **E:** Elective

SEMESTER I					
Course Code	T /P	D/U	C/E/O	Title of the course	No. of credits
ST - 11	T	U	C	Mathematical Analysis	5
ST - 12	T	U	C	Linear Algebra	4
ST - 13	T	U	C	Probability Distributions	5
ST - 14	T	U	C	Sampling Theory	4
ST - 15	T	U	C	Statistical Computing Techniques using R	2
ST - 16	P	D	C	Practicals - I	5
Note: ST-15(T,U,C) Unit 1 will have on-line ETE . Arrangements similar to practical examinations are to be made at the time of ETE. Unit 2 will have theory examination.				Total Credits	25
SEMESTER II					

Course Code	T /P	D/U	C/E/O	Title of the course	No. of credits
ST - 21	T	U	C	Probability Theory	6
ST - 22	T	U	C	Regression Analysis	4
ST - 23	T	U	C	Parametric Inference	5
ST - 24	T	U	C	Multivariate Analysis	5
ST - 25	P	D	C	Practicals- II	5
				Total Credits	25

Tentative structure for Semester III and IV shall be as follows.

Semester III

ST 31 (TUC) Elementary Stochastic Processes, 5 credits
ST 32 (TUC) Design of Experiments, 5 credits
ST 33 (TUC) Asymptotic Inference, 5 credits
ST 34 (TDE) Elective Course (Departmental Course)
ST 35 (PUC) Practicals-III, 5 credits

Semester IV

ST 41 (TUC) Optimization Techniques, 5 credits
ST 42 (TUC) Statistical Process Control, 3 credits
ST 43 (TUC) Non Parametric Inference, 2 credits
ST 44 (TUC) Time Series Analysis, 5 credits
ST 45 (TDE) Elective Course (Departmental Course)
ST 46 (PUC) Practicals-IV, 2 credits
ST 47 (PUC) Project, 3 credits.

ST 34: Elective Courses

E1. Clinical Trials, 5 credits
E2. Data Mining, 5 credits
E3. Measure Theory and Advanced Probability, 5 credits
E4. Advanced Inference, 5 credits
E5. Bayesian Inference, 5 credits
E6. Statistical Education, 2 credits
E7. Analysis of Directional Data, 2 credits

ST 45: Elective Courses

E8. Advanced Stochastic Processes, 5 credits
E9. Actuarial Statistics, 5 credits
E10.Discrete Event Simulation, 3 credits
E11. Demography, 2 credits
E12. Research Methodology, 2 credits
E13. Econometrics, 5 credits.

Note : Additional elective courses may introduced by taking approval from the Board of Studies.

6.c	**Question papers:** Pattern of question papers will be as specified in 5A

6.d	**Medium:** Medium of instruction and examination shall be English only
7.	**Equivalence:** The Head of the Department will decide as and when a case arises.
8.	**University Terms:** Time table for the beginning and end of the terms will be as announced by the University, which will be strictly followed.
9 and 10.	**Subject wise detailed syllabus and recommended books:** Detailed syllabi, along with the list of recommended books of the compulsory courses in the first year of M.Sc. are given below.

ST-11	**Mathematical Analysis, 5 Credits**	
Unit-1	Sets 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 rationals and uncountability of the real numbers, metric Spaces, interior point, exterior point, boundary point, limit point of a set, open set, closed set, compact sets, dense sets. Bolzano-Weierstrass and Heine-Borel Theorems (with proof) and their applications.	**12 L**
Unit-2	Sequences of real numbers, convergences and divergence of sequences and subsequences, Cauchy sequence, limit inferior, limit superior of the sequences, some special sequences.	**08 L**
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 of power series, addition and multiplication of the series, radius of convergence of Binomial, exponential, geometric and log series.	**10 L**
Unit-4	Real valued functions, limit of sequences of functions, continuity, uniform continuity, continuity and compactness, discontinuities of functions. The derivative of a real function, mean value theorem, the continuity of derivatives, L'Hospital's Rule(statement only), Taylor's Theorem (Statement only).	**10 L**
Unit-5	Riemann and Riemann-Stieltjes integrals, application in statistics, Cauchy-Schwartz inequality, Fundamental theorem of integral calculus, integration by parts, differentiation under the sign of integral.	**10 L**
Unit-6	Improper integrals of first and second kind for one variable, conditions for convergence of Beta and Gamma functions, relation between Beta and Gamma functions, properties of Beta and Gamma functions, Duplicate formula. Implicit Function theorem, Inverse Function theorem (without proof) and their simple applications.	**10 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. and 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. and Sherbert D. R. (2000), Introduction to Real Analysis (John Wiley and Son Inc.)
7. Royden H. L. (1988), Principles of Real Analysis (Macmillian)
8. Trench,W.F. (2012). Introduction to Real Analysis. E-book
(Can be downloaded from www.ramanujan.math.trinity.edu/wtrench/misc/index.html)

ST-12	**Linear Algebra, 4 Credits**	
Unit-1	Vector space, subspace, linear dependence and independence, basis of a vector space, dimension of a vector space, orthogonal and orthonormal vectors, orthonormal basis, Gram- Schmidt orthogonalization.	**8L**
Unit-2	Matrix algebra, special types of matrices, orthogonal matrix, idempotent matrix partitioned matrices, elementary operations, rank of a matrix, inverse of a matrix.	**8 L**
Unit-3	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.	**12 L**
Unit-4	g-inverse, Moore-Penrose g-inverse, solution of a system of homogeneous and non-homogeneous linear equations.	**10 L**
Unit-5	Quadratic forms: definition, reduction and classification, simultaneous reduction of two quadratic forms, maxima and minima of ratio of quadratic forms.	**10 L**

Books Recommended:

1. Searle S.R. (1982), Matrix Algebra Useful for Statistics, Wiley
2. Graybill, F.E. (1961), Introduction to Matrices with Applications in Statistics (Wadsworth Pub. Co.)
3. Rao C.R. (1973), Linear Statistical Inference and its Applications, Wiley Eastern
4. Hadley G. (1987), Linear Algebra, Narosa
5. Bellman, R. (1970), Introduction to Matrix Analysis. (Tata McGraw Hill)
6. Ramachandra Rao, A. and Bhimasankaram, P. (2000). Linear Algebra (Hindustan Book Agency)

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

ST-13	**Probability Distributions, 5 Credits**	
Unit-1	Brief review of a random variable (r.v.) , cumulative distribution function (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, moment generating function (m.g.f), moments, probability generating function (p.g.f), compound distributions.	**12 L**

Unit-2	Random vectors, joint probability distributions, joint m.g.f., mixed moments, variance covariance matrix, independence, sums of independent r.v. , convolutions, conditional expectation and variance, regression function and best linear regression function, multiple and partial correlation coefficients.	**12 L**
Unit-3	Bivariate Poisson, four types of bivariate exponential distributions, bivariate normal distribution, Dirichilet distribution and their properties.	**10 L**
Unit-4	Exponential class of distributions, location and scale families, non-regular families.	**06 L**
Unit-5	Review of order statistics, joint distributions of order statistics, probability integral transformation, distribution of rank factors, distributions of sign statistic, Kolmogorov-Smirnov statistic and Wilcoxon sign rank statistic.	**10 L**
Unit-6	Sampling distributions of quadratic forms and linear forms for random samples from normal distribution, Fisher Cochran theorem, Non-central chi-square, t, and F distributions.	**10 L**

Books Recommended:

1. Rohatagi V.K. and Saleh A.K.(2001) Introduction to Probability Theory and Mathematical Statistics. (John Wiley and sons)
2. Johnson N.L. Kemp A and Kotz S (2005) Univariate Discrete Distributions (John Wiley and sons Inc.)
3. Johnson N.L., Kotz S., Balkrishnan, N. (1994) Continuous Univariate Distributions, Vol. I (John Wiley and sons Inc)
4. Johnson N.L., Kotz S., Balkrishnan, N. (1995) Continuous Univariate Distributions, Vol. II (John Wiley and sons Inc)
5. Johnson N.L., Kotz S., Balkrishnan, N. (1996) Discrete Multivariate Distributions, (John Wiley and sons Inc)
6. Kotz S., Balkrishnan, N. and Johnson N.L., (2004), Continuous Multivariate Distributions (John Wiley and sons Inc)
6. Berger, R. and Casella G. (2002) Statistical Inference (Duxbury Resource Center) Second Edition.
7. Hogg R. V. and Craig T. T. (1978) Introduction to mathematical Statistics (Collier McMillan 4th edn.)
8. Rao B.L.S. P. (2009). A First course in probability and Statistics, (World Scientific, Singapore)

ST-14	**Samping Theory, 4 Credits**	
Unit-1	Basic finite population sampling techniques simple random sampling with replacement (SRSWR), simple random sampling without replacement (SRSWOR), related results on estimation of population total, probability proportional to size with replacement (PPSWR) methods, cumulative total method and Lahiri's method for estimation problem, estimation of finite population mean., Horwitz –Thompson estimator, its variance and properties,	**16 L**

	Midzuno scheme of sampling, determination of sample size in under various conditions.	
Unit-2	Stratified sampling, problem of allocation in stratified sampling, construction of strata , deep stratification, 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 the estimator of population mean under post-stratification.	**12 L**
Unit-3	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, 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.	**14 L**
Unit-4	Sampling and non–sampling errors, response errors, mathematical model for response errors, Hansen-Horwitz technique, randomized response technique (RRT). Warner's randomized response technique.	**06 L**

Books Recommended:

1. Sukhatme P.V., Sukhatme B.V. and C. Ashok Sampling theory of survey and applications (Indian society for Agricultural statistics)
2. Des Raj and Chandhok P. (1998), Sample survey theory (Narosa)
3. Cochran W. G., (1977) Sampling techniques (John Wiley and sons)
4. Murthy M.N. (1977) Sampling theory and methods (Statistical Publishing Society)

ST-15	**Statistical Computing Techniques Using R, 2 Credits**	
Unit-1	Introduction to R software: input, output statements, data types, statistical functions in R, vectors and vector arithmetic , data.frame., if…else, for, while, histogram, box plot, summary statistics, functions related to probability distributions (d, p, q, r); lm function, testing of hypothesis.	**12 L**
Unit-2	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,Newton's method . iv. Simpson's Trapezoidal rule for bivariate integrals v. Simulation of Linear congruential generator; Monte Carlo method to evaluate single and multiple integrals vi. Jack–Knife estimators vii. Boot strap methods.	**12 L**

	Books Recommended: 1. V. Rajaraman (1993): Computer Oriented numerical methods. (Prentice Hall) 2. Krishnamurthy V. and Sen (1993). Numerical Algorithm Computation in Science and Engineering (Affiliated East West Press 2nd Ed.) 3. Sastry, S.S. (2005) Introductory methods of Numerical Analysis. (Prentice Hall, 4th edition) 4. Purohit, S.G. ,Gore, S.D.and Deshmukh, S.R., (2008), Statistics using R (Narosa Publications).	

ST-16	**Practicals-I, 5 Credits** 1. Introduction to Statistical Software-I 2. Introduction to Statistical Software-II 3. **Matrices** Contents: Properties of Matrix, Inverse of matrix and non – singular matrix, inverse by partitioning.. 4. G-Inverse, MPG-Inverse 5. Eigen Value, eigen Vectors, Spectral Decomposition, Power of matrix. 6. Solution of System of Linear Equations by using Gauss elimination and Gauss Jorden methods. 7. Classification and Reduction of Quadratic forms. 8. Plotting of density function and distribution functions. 9. Model sampling from Gamma , Chi-square ,Weibull ,lognormal probability distribution. 10. Model sampling from mixture of distribution 11. Model sampling from bivariate probability distribution 12. Computation of probability of events related to bivariate probability distribution-II 13. Computation 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 unequal cluster size and Two stage sampling 18. N- R method , Grid , Bivariate interpolation. 19. Contains: Monte-Carlo method.By using Distribution Function 20. Computation of integral by Riemann and RS sums.	

ST-21	**Probability Theory, 6 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.	**08 L**

Unit-2	Probability measure on a measurable space, probability space, properties of probability measure: continuity, mixture of probability measures, Lebesgue and Lebesgue-Steltjes measures.	**06 L**
Unit-3	Measurable function, real and rector valued random variables (r.v.), simple r.v., r.v. as a limit of sequence of simple r.v.s, discrete and non-discrete r.v., distribution functions, decomposition of a distribution function.	**08 L**
Unit-4	Levy continuity Theorem, integration of a measurable function with respect to a probability measure, expectation of a r.v., properties of expectations, characteristic functions, properties, Parseval relation, uniqueness theorem, inequalities for moments.	**10 L**
Unit-5	Convergence of a sequence of r.v., almost sure convergence, convergence in rth mean, convergence in probability, convergence in distribution, their inter-relations, Khintchin's WLLN.	**10 L**
Unit-6	Independence of two and n (>2) events, sequence of independent events, π and λ systems. Dynkin's theorem (only introduction, without proof), independence of r.v.s, Borel zero-one law, Borel-Cantelli Lemmas.	**08 L**
Unit-7	Levy continuity theorem, Central Limit Theorem (C.L.T.) for i.i.d. r.v., Liaponove's form, Lindeberg-Feller form and their applications.	**10 L**

Books Recommended:

1. Bhat B.R.(1985) Modern Probability theory (Wiley Eastern)
2. Breiman (1968) Probability Theory (SIAM)
3. Billingsley P. (1986) Probability and Measure (Wiley)
4. Feller W. (1969) Introduction to probability and its applications Vol.II (Wiley Eastern)

ST-22	**Regression Analysis, 4 Credits**	
Unit-1	Simple linear regression, assumptions, least square (LS) estimators of parameters, standard error (s.e.) of estimators, testing of hypothesis for coefficient of regression, s.e. of prediction, testing of hypotheses about parallelism, equality of intercepts, congruence, extrapolation, optimal choice of independent variable, diagnostic checks and correction: graphical technique, tests for normality, correlated ness, homoscadasticity, lack of fit. Modifications like polynomial regression, transformations of dependent or independent variables, weighted LS, inverse regression.	**10 L**
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 of correlated observations, LS estimation with restrictions 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, and backward selection methods.	**10 L**
Unit-3	Multicollinearity: consequences, detection and remedies, autocorrelation: consequences, Durbin-Watson test, estimation of parameters in autocorrelation.	**4L**

Unit-4	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.	**12 L**
Unit-5	Non-linear regression: Non-linear least squares transformation to a linear model, statistical inference in non-linear regression.	**4 L**
Unit-6	Logistic regression: Logit transform, ML estimation,tests of hypothesis, Wald test, Likelihood ratio (LR) test, score test, test for overall regression, introduction to link functions such as binomial, inverse binomial, inverse Gaussian and Gamma.	**6 L**
Unit-7	Generalized linear models.	**2 L**

Books Recommended:

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-23	**Parametric Inference, 5 Credits**	
Unit-1	Sufficiency :- Factorization theorem, joint sufficiency , likelihood equivalence , minimal sufficiency, construction of minimal sufficient statistics, special classes of distributions admitting minimal sufficient statistics, Fisher information and information matrix.	**15 L**
Unit-2	Completeness, bounded completeness, complete sufficient statistics, special classes of distributions admitting complete sufficient statistics, incomplete minimal sufficient statistics, ancillary statistics, Basu's theorem and its applications, unbiased estimators, Uniformly minimum variance unbiased estimators (UMVUE), necessary and sufficient conditions for existence of UMVUE (with proof), Rao- Blackwell theorem, Lehman- scheffe theorem, and there uses, C-R inequality, regularity conditions , Minimum variance bound unbiased estimators (MVBUE), Chapman-Robin Bounds, Bhattacharya Bounds (with proof).	**20 L**
Unit-3	Test functions, Neymann-Pearson (NP) lemma (with proof), UMP tests for one-sided alternatives without nuisance parameters, exponential class of densities and extension to the distributions having MLR property.	**15 L**
Unit-4	Confidence intervals, relation with testing of hypothesis , shortest expected length confidence intervals, uniformly most accurate confidence intervals.	**05 L**

Unit-5	Introduction to Bayesian estimation, prior and posterior distributions, loss functions, principle of minimum expected posterior loss, quadratic and other common loss functions, conjugate family of prior distributions and its examples.	**05 L**

Books Recommended:

1. Kale B.K. (1999) A First course on Parametric Inference (Narosa)
2. Casella G. and Beregar R.L. (2002) Statistical Inference, 2nd Edition (Duxbury Advanced Series)
3. Dudewitz E.J. and 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. (2001) An Introduction to Probability and Statistics (John Wiley and sons)

ST-24	**Multivariate Analysis, 5 Credits**	
Unit-1	Exploratory multivariate data analysis : Sample mean vector, dispersion matrix, correlation matrix. mean, variances covariances, correlation of linear transformations. Graphical representations.	**06 L**
Unit-2	Principal component analysis, factor analysis, canonical correlation, cluster analysis and applications.	**18 L**
Unit-3	Multivariate normal distribution, singular and non-singular normal distributions, moment generating functions (m.g.f.), characteristic functions, moments, distribution of a linear form and a quadratic form of normal variables, marginal and conditional distributions. Multiple regression and multiple and partial correlation coefficients. Test of significance for Multiple regression and multiple and partial correlation coefficients.	**12 L**
Unit-4	Maximum likelihood estimators (M.L.E.) of parameters of multivariate normal distribution and their sampling distributions. Wishart matrix, Wishart distribution and its properties.	**08 L**
Unit-5	Tests of hypothesis about mean vector of a multivariate normal population. Likelihood ratio test. Hostelling T^2 statistic and its distribution, its applications, relationship with Mahalanobis D^2 statistic, confidence regions for mean vector of a multivariate normal Distribution. Discriminant analysis.	**16 L**

Books Recommended:

1. Anderson T.W.(1984), Introduction to multivariate analysis (John Wiley)
2. Kshirsagar A.M. (1983), Multivariate Analysis (Marcel Dekker)
3. Rao C.R. (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. Härdle, W. K., Hlávka, Z. (2007), Multivariate Statistics: Exercises and Solutions (Springer, New York)

8. Härdle, W. K. and Simar, L. (2012) , Applied Multivariate Statistical analysis (Springer, New York)

ST-25	Practicals-II, 5 Credits
	1. Simple regression and regression diagnostics. 2. Multiple regression. 3. Lack of fit of the regression model. 4. Multiple regression (selection of variable). 5. Nonlinear regression models. 6. Multicollinearity and orthogonal polynomial regression. 7. Logistic regression. 8. Generalized Linear Model and Poisson regression. 9. Applications of Central Limit Theorem and weak law of large numbers. 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 Maximum likelihood estimators (M.L.E.) of parameters. 17. Likelihood ratio test. 18. Application of Hotelling T^2 statistics. 19. Discriminant analysis.

11. Qualification of Teachers: As per the University rules

12. Notes for implementation of the program:

a. Number of lectures per credit is 12, (10 Theory + 2 for Tutorials seminars, tests etc.)
b. Each practical course will require 6 hours of laboratory work per week and the course will be examined at the end of each semester.
c. There should not be more than 10 students in a batch for M.Sc. practical course.
d. Two interactive sessions per course per semester must be conducted by concerned teachers.
e. Each theory course will be examined for out of 20 marks per credit (Total marks =20xNumber of credits) of which 75% marks are reserved for end of term examination (ETE) at the end of the semester and 25% marks for internal assessment (CIA).
f. There would be Continuous Internal Assessment (CIA) and an End of Term Examination (ETE) for each course. CIA includes examinations, assignments, small projects, viva-voce examinations and presentations seminars, quizzes etc.
g. Final practical examination will be 3 hours duration. It will be for 75 marks of which 10 marks will be reserved viva at the time of examination.
h. There shall be 25 marks for internal evaluation for each practical course,10 marks are reserved for journal and15 marks for viva at the completion of every experiment and internal test.

i. For departmental course, college should appoint one external, paper setter or examiner for the final examination.
j. In order to acquaint the students with applications of statistical methods in various fields such as industries, agricultural sectors, government institutes etc. at least one study tour of M.Sc. Statistics students must be arranged.
k. Class Improvement: A candidate who has passed the examination of this University in lower class can apply under the class improvement scheme within five years from the passing of that examination only in 3 attempts, according to the syllabus in existence, for at least 1/3 theory courses, excluding departmental course, for ETE. Performance of the remaining heads will be carried forward.