DEPARTMENT OF STATISTICS
SAURASHTRA UNIVERSITY RAJKOT

M. Sc course in Statistics is meant for two years spread in four semesters. There are four theory papers and one practical papers in each semester. Each of the theory and practical papers consists of 100 marks. Further each practical paper is partitioned into two papers each if 40 marks, 10 marks for journal certifications and another 10 marks for viva-voce from Semester I to IV. However in Semester IV, the practical paper is partitioned into two papers namely, (Practical of 40 marks, journal certification of 10 marks and (ii) Project work of 40 marks, viva-voce of 10 marks.

SYLLABUS FOR M. Sc. STATISTICS

SEMESTER – I

S-1001 Linear Algebra
S-1002 Probability Theory
S-1003 Distribution Theory
S-1004 Statistical Inference I and Nonparametric
S-1005 Practical based on S-1003, S-1004
S-1005(a) based on S-1003 and Nonparametric
S-1005(b) based on Estimation Theory

SEMESTER – II

S-2001 Sample Surveys
S-2002 Linear Models and Regression Analysis
S-2003 Design of Experiments
S-2004 Statistical Inference II and Decision Theory
S-2005 Practical based on S-2001, S-,2003 and 2004
S-2005(a) based on S-2001 and S-2004
S-2005(b) based on S-2003

SEMEATER – III

S-3001 Computer Programming C^{++}
S-3002 Operations Research
S-3003 Stochastic Process
S-3004 Econometrics
S-3005 Practical based on S-3001, S-3004
S-3005(a) based on S-3001
S-3005(b) based on S-3004

SEMESTER – IV

S-4001 Advance Design of Experiments
S-4002 Statistical Computing
S-4003 Bio-Statistics
S-4004 Multivariate Analysis
S- Practical and Project
S-4005(a) based on S-4001 and S-4004
S-4005(b) Project

The Syllabus of M. Sc. Statistics(Semester I to IV) has been implemented with effect from academic year 2005-2006.

SEMESTER – I

Paper:S-1001 LINEAR ALGEBRA

1. Vector Spaces, subspaces, linear dependence and independence, basis and dimension of vector space, finite dimensional vector spaces. Example of vector spaces over real and complex variables.
2. Vector spaces with an inner product, Gram- Schmidt orthogonalization process, orthonormal projection of a vector.
3. Linear transformations, Algebra of matrices, row and column spaces of a matrix, elementary matrices, determinant, rank and inverse of a matrix, portioned matrices and Kronecker product.
4. Canonical form, Hermite canonical form, diagonal form, triangular form, Jordan form, quadratic form, generalized inverse, Moore- Penrose generalized inverse, idempotent matrices.
5. Characteristics roots and vectors, algebraic multiplicity of a characteristic roots. Caley-Hamilton theorem, spectral decomposition of a real symmetric matrix.

References:

1. Grabill, F.A. (1983). Matrices with applications in Statistics, 2nd edition, wadsworth.
2. Rao, C. R. (1973). Linear Statsitical Inference and its applications, 2nd edition. John wiley and sons.
3. Searle, S. R. (1982). Matrix algebra useful for Statistics. John Wiley and sons.
4. Biswas, S. (1984). Topics in algebra of matrices, Academic publications.
5. Hadley, G. (1987). Linear algebra, Narosa publishing house.
6. Rao, C. R. and Bhimsankaran, P. (1992). Linear Algebra, Tata McGraw Hill.
7. Rao, C. R. and Mitra S. K. (1971). Generalized iverse of matrices and its applications. John Wiley and sons.

SEMESTER – I

Paper: S-1002 PROBABILITY THEORY

1. Probability Spaces, random variables, expectations and moments, Minkowski inequality, Schwartz inequality, Jensen inequality, Markov inequality, Holder's inequality and Tchebyshev's inequality.
2. Classes of sets, field, sigma fields, minmal sigma fields, Borel sigma fields. Lim sup and lim inf of a sets. Measure, Probability measure, properties of measure. Catheodary extension theorem(statement only), Lebesgue and Lebesgue – Steljes measures, measurable functions.
3. Integration of measurable function with respect to a measure, Monotone Convergence theorem, Fatou's lemma, Dominated Convergence theorem, Radon-Nykodin theorem (Statement only).

4. Law of large numbers: Weak law of large numbers, Strong law of large numbers for i. i. d. sequence, strong law of large numbers, Kolmogorov's strong law of large numbers. Borel 0-1 law, Bore l- Cantelli lemma, Kolmogorov 0 – 1 law.
5. Convergence in Probability, in distribution and in mean. Central limit theorem for a sequence of independent random variables under Lindberg's condition, Liapounov's CLT (only statement).

References:

1. Asb Robert. (1972). Real analysis and probability, Academic Press.
2. Billingsley, P. (1986). Probability and Measure Wiley .
3. Kingman J.F.C. and Taylo S. J. (1966). Introducton to measure and probability. Cambridge University Press).

SEMESTER – I

Paper: S-1003 DISTRIBUTION THEORY

1. Brief review of basic distribution theory. Joint, Marginal and Conditional probability mass function (pmf) and probability density function (pdf) , Discrete and continuous distributions.
2. Function of random variables and their distributions using Jacobin of transformation and their tools, probability distribution of a random variables, properties of distribution functions, Characteristics functions and its properties, Inversion theorem, uniqueness theorem and Convolutions.
3. Power series distribution: its mean, variance, mgf, cgf, and recurrence relations. Various discrete distributions as its particular cases.
4. Sampling distributions: Non central chi square, t and f – distributions and their properties. Distributions of quadratic form under normality.
5. Order statistics: their distribution and properties, joint and marginal distributions of order statistics. Extreme values and their asymptotic distributions (Statement only) and its applications.

References:

1. Rohatgi, V. K. (1984). An introduction to probability theory and mathematical statistics. New age International Publication.
2. Rao, C. R. (1973). Linear Statsitical Inference and its applications, 2nd edition. John wiley and sons.
3. Johnson, S. and Kotz (1972). Distributions in Statistics. Vol I, II, III. Houghton and Maffin publication.
4. Cramer, H. (1946). Mathematical methods of Statistics. Princeton.

SEMESTER – I

Paper: S-1004 STATISTICAL INFERENCE AND NON PARAMETRIC TESTS

1. Viewed on unbiasedness, efficiency, consistency and sufficiency. Neyman factorization theorem, minimal sufficient statistics.
2. Method of estimations: maximum likelihood method, method of moments, minimum chi square method. Minimum variance unbiased estimators, Rao-Blackwell theorem. Completeness, Lehman – Scheffe's necessary and sufficient condition for MBUE, Cramer – Rao lower bound approach and Bhattacharya's system of lower bounds for a single parameter.
3. One sample U Statistics, Two sample U Statistics, Asymptotic distributions of U Statistics, UMVUE, property of U Statistics.
4. Rank test, locally most powerful rank test, linear rank statistics and their distributional properties under null hypothesis.
5. One sample location problem, sign test, signed rank test, two sample Kolmogorov – Smirnov tests. Two sample location and scale problems. Wilcoxon – mann – Whitney tests. Krusal – Wallis k sample tests.

Reference:

1. Kale, B.K. (1999). A first course on parametric inference. Narosa
2. Rohatgi, V. K. (1984). An introduction to probability theory and mathematical statistics. New age International Publication.
3. Rao, C. R. (1973). Linear Statsitical Inference and its applications, 2nd edition. John wiley and sons.
4. Furguson, T.S. (1967). Mathematical Statistics, Academic Press.
5. Zacks, S. (1989). Theory of Statistical Inference. John Wiley and sons.
6. Gibbons, J. D. (1985). Non parametric Statistical Inference, 2nd edition, Marcel Dekker.
7. Hajek, J. and Sidak, Z. (1967). Theory of rank tests. Academic press.
8. Fraser, D.A.S. (1957). Non parametric methods in Statistics. John wiley and sons

SEMESTER – II

Paper: S-2001 SAMPLE SURVEY

1. Varying probability sampling: PPS Sampling, estimation od population mean. Gain due to PPS sampling. Procedure of selecting PPS sampling (Cumulative total method and Lahiri's method), Midzuno scheme of sampling, Horvitz – Thompson estimator, its variance, variance estimators due to Horvitz – Thompson estimator under Yates and Grundy scheme.
2. Two stage sampling: Estimation and sampling variance. Double samplimg, multistage sampling, cluster sampling.
3. Ratio estimator: Bias and mean square error of the ratio estimation, estimation of bias and mean square error of the ratio estimator. Unbiased or almost unbiased ratio type estimator. Product estimator.
4. Regression estimator: Bias and mean square error of the regression estimator, efficiency of regression estimator. Non sampling error.
5. Control chars for variables and attributes. Acceptance sampling by attributes. Single, double and sequential sampling plans: OC, ASN functions, AOQL and ATI: Acceptance sampling by variables.

Reference:

1. Cochran, W. G.(1977). Sampling Technique. 3rd edition, New age international publishers.
2. Desraj and Chandak. (1978). Sampling Theory. Narosa.
3. Murthy, M. N. (1977). Sampling theory and methods. Statistical publishing society. Kolkatta.
4. Sukhatme et. Al. (1984). Sampling theory of survey with applications. IOWA state, University press and IASRI publications.
5. Singh, D. and Chaudhary, F. S. (1986). Theory and analysis of sample survey designs. New age international publishers.
6. Mukhopadhyay, P. (1988). Small area estimation in survey sampling. Narosa.

SEMESTER – II

Paper: S-2002 LINEAR MODELS AND REGRESSION

1. Standard Gauss – Markov models: Estimability of parameters, Best linear unbiased estimator (BLUE), method of least square and Gauss – Markov theorem, Variance and Covariance of BLUE.

2. Fixed, Random and Mixed effect models, Analysis of variance of one way and two way classifications. Orthogonal and Non orthogonal data. Analysis of variance of Orthogonal and Non orthogonal data.
3. Introducing of one way random effects linear models and estimation of Variance components.
4. Maximum likelihood, MINQUE and restricted maximum likelihood estimators of variance components, best linear unbiased predicators(BLUP).
5. Bi-variate and multiple linear regression, polynomial regression, use of orthogonal polynomial. Linear and non-linear regression models.

References:

1. Cook, R.D. and Weisberg's (1982). Residual and influence in Regression. Chapman and hall.
2. Draper, N.R. and Smith, H.(1998). Applied regression analysis, Third Ed. John Wiley.
3. Grust, R.F. and Mason, R.L.(1980). Regression analysis and its applications-A data oriented approach, Marcel and Dekkar.
4. Rao, C.R.(1973). Linear Statistical Inference and its application, New age international publication.
5. Rao, C.R. and Kleffe, J.(1988). Estimation of variance component and applications, North Holland.
6. Weisberg, S.(1985). Applied linear regression, Wiley, John
7. Searle, S.R. , Caselle, G. and Mccullocb, C.E. (1992). Variance components, Wiley John.
8. Seber, G. A. and Wild, G.J. (1989). Nonlinear regression, Wiley John.

SEMESTER 2

P:S-2003 DESIGN OF EXPERIMENTS

1. Introduction to designed experiments. General block design and its information matrix C. Properties of block design: Connectedness, balance and orthogonolitig.

2. Balanced incomplete block design, its properties, parametric relations, intra block analysis of BIB design. Youden squares design, intra block design analysis of Yauden square design.

3. Lattice design: simple and balanced lattice design. Analysis of lattice design. Missing plot techniques, estimation of missing observation and its analysis of variance of RBD, LSD and BIB design.

4. General factorial experiment, main effects and interaction effects. 2^n and 3^n factorial experiment. Analysis of 2^n and 3^n factorial experiments in randomized block. Confounding experiments: complete partial and balanced confounding and its ANOVA table. Split and strip plot designs.

5. Analysis of covariance in a general grass-markov model, applications to standard designs. Response surface designs: first order and second order response surface designs. Second order rotable designs.

References:

1. Aloke dey (1986). Theory of block designs, new age international publication
2. Angela dean and Daniel Voss (1999). Design and analysis of experiments, new age international publication.
3. Das, M .N. and Giri N. (1979). New age international publication.
4. John P.W.M. (1971). Statistical design and analysis of experiments. Macmillan
5. Joshi, D.D. (1987). Linear estimation and design of experiments. New age international publication.
6. Montgomery, C.D.(1976). Design and analysis of experiments, John Wiley, New York
7. Pearce, S.C. (1984). Design of experiments, John Wiley, New York.
8. Myers, R.H. (1971). Response surface methodology, Allyn and Bacon.

SEMESTER 2

P: S 2004 STATISTICAL INFERENCE AND DECISION THEORY

1. Statistical decision problem: Non randomized and randomized decision rules. Loss function, expected loss, risk function. Concept of admissibility, Bayes rule, admissibility of Bayes's rules.

2. Minimax rules, least favorable distributions, complete class and minimal complete class. Decision problem for finite parameter space. Convex loss function. Bayes minimax estimators, illustrations.

3. Test of hypothesis: simple and composite hypothesis, two types of errors, critical regions, randomized tests, power function, and most powerful and most powerful tests. Neyman Pearson lemma, generalized Neyman Pearson lemma.

4. Unbiased tests: uniformly most powerful unbiased test, similar test, relation between UMP unbiased test and a UMP similar test, application to one parameter exponential family. Tests with Neyman structure. Inference on scale and location parameters: estimation and tests.

5. Interval estimation, confidence level, construction of confidence interval using pivots, shortest expected length confidence interval, uniformly most accurate one sided confidence

interval and its relation with UMP test for one sided null against one sided alternative hypothesis.

References

1. Berger B.O. (1985). Statistical design theory and Bayesian analysis, 2^{nd} edition, Springer.
2. Ferguson, T.S. (1967). Mathematical statistics and design theory approach. Academic press.
3. Lehmann, E.L. (1986). Theory of point estimation. (student edition)
4. Lehmann, E.L. (1986). Testing statistical hypothesis (student edition).
5. Zacks, S. (1971). Theory of statistical inference. John Wiley and sons.

SEMESTER 3

P: S 3001 COMPUTER PROGRAMMING C ++

1. Introduction to object oriented programming, concept and designing: numerical constants and variables, integer: int, short, long, signed and unsigned, floating point: float and double. Character variable.

2. Control statement: relation operators, compound statement, if, if else, while loop, for loop, do while loop, logical operators, switch and break statement.

3. Array: array variable, syntax rules for arrays, multiple subscripts in arrays, for loops with arrays, functions: defining and using functions. Function declaration, array in function, global, local and static variable. Strings: character data type, input and output of strings.

4. Pointers: pointers data type, pointers and address, pointers and arrays, pointers to functions, pointer to pointer. Recursion: recursive function, recursion vs. iteration.

5. Writing program for statistical calculation

    - ♣ Addition, subtraction and multiplication
    - ♣ Correlation, regression, t-test, chi square test, r x c contingency table.
    - ♣ Analysis of variance (CRD, RBD, LSD, and BIBD)
    - ♣ Sampling procedure
    - ♣ Other related statistical problems

References
1. R. Decker and S. Hirshfield (1998). The object concept: an introduction to computer programming using c++, PWS publishing.
2. S.B. Lipmann and J. Lajoie (1998). C++ primer. Third ED. Addison Wesley.
3. W.J. Savitch (2001). Problem solving with c++. The object of programming. Third ED. Addison Wesley, Longman.

SEMESTER 3
P: S 3002 OPERATIONS RESEARCH

1. Linear programming problem: feasible, basic feasible and optimal solution. Example of LPP. Solution of LPP using graphical method.

2. Simple method, revised simple solution, dual, dual simple method.

3. Transportation and assignment problem (both balanced and unbalanced case). Game theory: Two person games, pare and mixed strategies, finding solution in 2 x 2, 2xm, and m x n games. (Equivalent of rectangle game and linear programming.)

4. Basic characteristics of queuing system, different performance measures, steady state solution of /markov queuing models: m\m\1, m\m\1 with limited waiting space, m\m\c, m\m\c with limited waiting space.

5. Inventory problems and analytical structure. Simple deterministic and stochastic models of inventory controls. Replacement problems: block and age replacement policies, dynamic programming approach for maintenance problems; replacement of terms with long life, PERT and CPM. Sequencing and scheduling problems.

Reference:
1. Taha, H.A. (1982). Operational research: an introduction; Macmillan.
2. Kantiswaroop, gupta, P.K. and Singh, M.M. (1985). Operations research, sultan chand and sons.
3. J.K. Sharma (1990). Mathematical models in operation research. Tata McGraw hill.
4. Hadely, g. (1964). Non linear and dynamic programming. Addison Wesley.

SEMESTER 3
P: S 3003 STOCHASTIC PROCESSES

1. Introduction to stochastic process (sp's): classification of sp's according to state space and time domain. Countable state markov chain (mc's), stationary process, classification of states, transition probability, Chapman kolmogorow questions, calculations of n steps transition probability (higher transition probability) and its limit.

2. Random walk and gambler's ruin problem: effect of changing bet, duration of game, probability of gamblers ruin in exactly n games, one and two dimensional random walk.

3. Poisson process: introduction, probability mass function, probability generating function and property of Poisson process.

4. Birth process: Yule fury process, death process, birth and death process, its distribution, mean and variance, wiener process.

5. Branching process: Galton Watson branching process, its mean and variance, probability of ultimate extinction.

Reference:

1. Adke, S. and Manjunath, S.M. (1984). An introduction to finite markov process, new age international.
2. Guttrop, P. (1991). Statistical inference for branching process, Wiley.
3. Bhatt, B.R. (2000). Stochastic modules, analysis and applications, new age international, New Delhi.
4. Medhi, J. (1982). Stochastic process, new age international, New Delhi.
5. Ross, S.M. stochastic process, new age international, New Delhi.

SEMESTER III

Paper S-3004 ECONOMERICS

1. Nature of econometrics: the general model (GLM) and its existence. Ordinary least square (OLS) estimation and prediction. Use of dummy variables. Generalized least square (GLS) estimation and prediction. Heteroscedastic disturbance.

2. Auto correlation, its consequences and tests. Theil BLUE procedure. Estimation and prediction. Multi collinearity problem, its implication and tools for handling the problem. Ridge regression.

3. Linear regression and stochastic regression. Instrumental variable equation, error in variables. Auto regressive linear regression. Distributed Lag models.

4. Simultaneous linear equations model. Examples Identification problem. Restriction on structural parameter rank and order condition.

5. Estimation on simultaneously equation model, 2 SLS estimators, limited information estimator, 3 SLS estimation, full information maximum likelihood method. Monte Carlo studies and simulation.

Reference:

1. Apte, P.G. (1990). Text book of econometrics. Tata McGraw hill.
2. Gujarathi, D. (1979). Basic econometrics, Tata McGraw hill.
3. Klein, L.R. (1962). An introduction to econometrics, prentice hall of India.
4. Thiel, H. (1982). Introduction to the theory and practice of econometrics, John Wiley.
5. Johnston, J. (1984). Econometric methods, 3rd edition, Tata McGraw hill.

SEMESTER 4

P: S 4001 ADVANCE DESIGN OF EXPERIMENTS

1. Finite group and finite field geometry projective and Euclidean. Mutually orthogonal lattice square design. Construction of (1) MOLS and (2) BIB designs using MOLS, PG (N, S), EG (N, S) and other methods. Recovery of inter block analysis of BIB design.

2. Two associated PBIB design association scheme and intra block analysis. Group divisible designs, dual and linked block designs, resolvable and affined resolvable designs. General row column designs and its intra block analysis.

3. Confounded designs, fractional factorial designs and their constructions. Orthogonal and their balanced array and their connection with confounded and fractional factorials. Construction of (1) orthogonal array (2) orthogonal main effect plans and (3) response surface designs.

4. Optimum designs: various optimality criteria and their interpretation, optimality of BIB design, optimal chemical balance weighing designs, Robustness of BIB design against the loss of 1<=s<=k observation in a block.

5. Diallel Crosses: complete diallel crosses, its analysis and efficiency factor, optimal diallel crosses plane. Robustness of designs. Robustness of diallel crosses plan against the lost of 1<=s<=k observation in a block.

Reference:

6. Bose, R.C. and Shimamoto, T. (1952). Classification and analysis of PBIB design with two associate classes. Jr. American Stat. Assoc. Vol. 47, pp151-189.
7. Chakrabarty, M.C. (1962). Mathematics of design of experiments. Asia pub. House.
8. Das, M.N. and Giri, N. (1975). Design and analysis of experiments. New age international publication.
9. Das, A. (1986). Theory of block designs. New age international publication.
10. John, P.W.M. (1971). Statistical design and analysis of experiments Macmillan.
11. Khuri, A. and Cornell, M. (1991). Response surface methodology. Marcel Dekker.
12. Raghavarao, D. (1971). Construction and combination problem in design of experiments. John Wiley.
13. Shah, K.R. and Sinha, B.K. (1989). Theory of optimal design. Springer Verlag.

SEMESTER 4
P: S 4002 STATISTICAL COMPUTING

1. Windows: use of windows, its operations and applications.
   MS word: operations of MS word and applications.

2. MS excel: use of MS excel, its operations, solution of statistical problems using MS excel.

3. MATLAB/MINITAB: use of MATLAB/MINITAB, computation of statistical problem using MATLAB/MINITAB.

4. SPSS: uses of SPSS, computation of statistical problem using SPSS.

5. WEB/INTERNET/EMAIL: concept of WEB, INTERNET and EMAIL and its application.

Reference:
1. B. Ryan and B.L. Joiner (2001). Minitab Handbook, 4^{th} edition, Duxbury.
2. R.A. Thisted (1988). Elements of statistical computing. Chapman and hall.

SEMESTER 4
P: S 4003 BIO STATISTICS

1. Type of biological assays: direct assays, indirect assays, parallel line assays. Ratio estimators, asymptotic distributions.

2. Regression approaches to estimating dose. Response relationship. Logit and probit approaches when dose response curve for standard preparation is unknown, quantal responses, method of estimation of parameters.

3. Introduction to clinical trials: the need and ethicks of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of phase 1-4 trials.

4. Cross over designs. Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. Longitudinal designs, review of factorial designs, objectives and end points of clinical trials, design of phase 1 trials, design and monitoring of phase 3. Trials with sequential stopping.

5. Reporting and analysis ;analysis of categorical outcomes from phase I-III

   Trials,analysis of survival data from clinical trials.

References:

1. Z.-Govindarajulu (2000). Statistical technique in Bioassay, S.Kargar.
2. J.Finney(1971).Statistical methods in Bioassay, Griffin.
3. J.Finney (1971). Probit analysis (3rd edition), Griffin.
4. Das, M.N. and Giri, N. (1975). Design and analysis of experiments. New age international publication.
5. S. Piantadosi(1997). Clinical trials. A methodological perspective. Wiley & sons.
6. L.M., Friedman, C. Furburg, D.L.Demets. Fundamentals of clinical trials,Springer verlag.
7. J.L. Fleiss(1989). The design and analysis of clinical experiments, Wiley & sons.
8. E. Marubeni and M.G. Valsecchi (1994). Analyzing survival data from clinical trials and observational studies, Wiley & sons.

SEMESTER 4

P: S 4004 MULTIVARIATE ANALYSIS

1. Singular and non-singular multivariate distributions. Multivariate Normal distribution: Marginal and conditional distributions, characteristics functions, distribution of linear

forms and quadratic forms. Maximum likelihood estimators of parameters of multivariate normal distributions.

2. Null Distribution of Hoteling's T^2 statistics. Application in tests on mean vector for one and more multivariate populations and also one quality of the components of a mean vector in a multivariate normal distribution. Mahalanobis D^2 .
3. Whishart Matrix: Its distributions and properties.
4. Classification and discrimination procedure for discrimination between two multivariate normal populations. Linear discrimination function : Test associate with discriminate functions. Classification into more than two multivariate normal populations.
5. Principal Components, Dimension reduction, Canonical variables and canonical correlation: definition, use, estimation and computation.

Reference:

1. Anderson, T.W.(1983). An introduction to multivariate statistical analysis,2nd ,edition, John Wiley.
2. Kshirsagar, A.M.(1972). Multivariate analysis.Marcel Decker.
3. Muirhead, R.J.(1982). Aspects of multivariate statistical theory. John Wiley.
4. Rao, C.R. (1973). Linear Statistical Inference and its application, 2nd edition, John Wiley.
5. Sharma, S. (1996). Applied Multivariate techniques, John Wiley.
6. Srivastva, M.S. and Khatri, C.G.(1979). An introduction to multivariate statistics. North Holland.