Revised Syllabi of M.A./M.SC. in Statistics

1) **Title of the course:** M. A. / M. Sc. in Statistics
2) **Pattern:** Semester and Credit system with pre-requisites for some courses

The M. A. / M. Sc. program in Statistics consists of 100 credits. Credits of a course are specified against the title of the course. A course with T in brackets indicates that it is a theory course whereas a course with P in brackets indicates that it is a practical course. Some of the practical courses are linked with a theory course and in such a case, both the courses will have the same number with T and P, indicating a theory and a practical course respectively. A student can enroll for a practical course if

(i) (s)he has enrolled for the corresponding theory course(as indicated) in the same term
or
(ii) (s)he has passed the corresponding theory course in an earlier term
or
(iii) terms for the corresponding theory course have been granted in an earlier term.

Some courses have pre-requisites as specified. Unless a student passes the pre-requisites of a course, (s)he will not be allowed to enroll in the said course. Pre-requisites of a course are indicated in curly brackets against the course. The Head of the Department, if necessary, may change the pre-requisites of a course on recommendations of the Departmental Committee.

3) Eligibility

For M. A. in Statistics following candidates are eligible.
(i) B.A. (Second class) with Statistics as principal and Mathematics at subsidiary level,
(ii) B.A. (Second class) with Mathematics as principal and Statistics at subsidiary level,
(iii**)** M.A. (First class) in Mathematics,
(iv) M.A. (First class) in Biometry.

For M. Sc. in Statistics following candidates are eligible.
(i) B.Sc. (Second class) with Statistics as principal and Mathematics at subsidiary level,
(ii) B.Sc. (Second class) with Mathematics as principal and Statistics at subsidiary level,
(iii**)** M.Sc. (First class) in Mathematics,
(iv) M.Sc. (First class) in Biometry.

4) Examination

A) (i) Pattern of examination: There would be continuous internal assessment (CIA) and an end of term examination (ETE) for each course. CIA includes examinations, assignments, viva-voce examinations and presentations.
(ii) Pattern of the question paper: For a compulsory course with 5 credits, a student is given an option to attempt 5 out of 8 questions.

B) Standard of passing: A student has to obtain 40% marks in the combined grading of ETE and CIA for passing the course, with a minimum passing of 30% in both CIA and ETE separately.

C) ATKT rules: A student can register for the third semester, if s/he completes 50% credits of the total credits expected to be completed within first two semesters, subject to the pre-requisite system mentioned above. Once registered, a student should complete M.A./ M.Sc. within a period of 4 years (8 semesters).

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

E) External students: Not applicable

F) Setting of question paper: The Department has been given autonomy for setting and grading of the papers. A teacher teaching a course sets the paper of the course and it is moderated by a committee of subject experts from other universities.

G) Verification or revaluation: As per the University rules

5) **Structure of the course**

(i) a) Compulsory papers

Compulsory courses in semester I and semester II are listed below.

Semester I

ST 1 Mathematical Analysis (5)
ST 2 (T) Linear Algebra (3)
ST 2 (P) Linear Algebra (2)
ST 3 (T) Probability Distributions (5)
ST 3 (P) Probability Distributions (1)
ST 4 Multi-dimensional Calculus (3)
ST 5 (T) Numerical Analysis and Programming (2)
ST 5 (P) Numerical Analysis and programming (3)

Semester II

ST 6 Probability theory (5) {ST 1}
ST 7 (T) Regression Analysis (4) {ST 2 (T), ST 3(T)}
ST 7 (P) Regression Analysis (2)
ST 8 Parametric Inference (5) {ST 3 (T)}
ST 9 (T) Multivariate Analysis (4) {ST 3(T), ST 4, ST 2(T)}
ST 9 (P) Multivariate Analysis (2)
ST 10 Stochastic Processes I (4)

In semesters III and IV some courses are compulsory and some are optional. List of optional courses is given in 5(b).

Semester III

ST 11 (T) Asymptotic Inference (5) {ST 6 and ST 8}
ST 11 (P) Asymptotic Inference (2)
ST 12 (T) Design of Experiments and Analysis of Variance (4) {ST 7(T)}
ST 12 (P) Design of Experiments and Analysis of Variance (2)
ST 13 Stochastic Processes II (2)
Optional course I (5)
Optional course II (5)

Semester IV

ST 14 (T) Sampling Methods (4)
ST 14 (P) Sampling Methods (2)
ST 15 (P) Project (4)
Optional course I (5)
Optional course II (5)
Optional course III (5)

The compulsory courses in all the semesters are the core courses. These have 75 (55 (theory) + 20 (practical)) credits in all.

A student may be allotted a module by the Department at the beginning of the second year of the program. The allotment is based on the performance of students as indicated by her/his rank among all the students given admission in the same year. A total of 15 credits should be obtained from the courses listed as module specific courses. The remaining 10 credits need to be obtained from the optional courses listed in 5(b) or from courses from other departments, as allowed by the University.

The Head of the Department may not allow a student to continue with the allotted module and such a student can complete M.A. /M.Sc. in Statistics without having offered any module, subject to the requirement of at least 80 credits obtained from the courses offered by the Department, as described below.

A student can opt for a project in lieu of an optional course or two optional courses with the permission of the Head of the Department. A copy of rules and regulations regarding completion and submission of the project work by a student and assessment of the project work is available in the Department.

Below is given a list of 4 modules. Courses specific to a given module are also listed. Each of these courses, called as a module-specific course, has 5 credits.

A project can have either 5 credits or 10 credits. A project with 5 credits has to be completed within a semester. A project with 10 credits will be spread over two semesters; work in each semester is to be counted for 5 credits. A student can opt for two different projects also, each having 5 credits.

Modules

M1. Probability and Mathematical Statistics

M2. Industrial and Financial Statistics

M3. Bio-Statistics

M4. Computational Statistics

List of module specific courses

Module 1: Probability & Mathematical Statistics.

ST P1 Measure theory and Probability {ST 6}
ST P2 Advanced Stochastic Processes {ST 6, ST 10}
ST P3 Decision Theory and Bayesian Inference {ST 8}
ST P4 Advanced Multivariate Analysis {ST 9 (T)}
ST P5 Inference in Stochastic Processes {ST 10, ST 11, ST 13}

Module 2: Industrial and Financial Statistics

ST I1 Optimization Techniques {ST 2(T)}
ST I2 Statistical Methods for Quality and Reliability {ST 3 (T)}
ST I3 Survival Analysis {ST 11 (T)}
ST I4 Time Series {ST 7 (T)}
ST I5 Actuarial Statistics {ST 3 (T)}
ST I6 Stochastic models in Finance {ST 10 (T), ST 13}

Module 3: Bio-Statistics

ST B1 Statistical Ecology {ST 3 (T)}
ST B2 Statistical Genetics {ST 3 (T)}
ST B3 Survival Analysis {ST 11 (T)}
ST B4 Analysis of Clinical Trials {ST 7 (T), ST 12 (T)}
ST B5 Actuarial Statistics {ST 3 (T)}
ST B6 Medical and Health Statistics {ST 3 (T)}

Module 4: Computational Statistics

ST C1 Statistical Simulations {ST 3 (T), ST 5(T), ST 5(P)}
ST C2 Computer-Intensive Statistical Methods {ST 5 (T), ST 11 (T)}
ST C3 Advanced Computer Programming {ST 5 (T), ST 5 (P)}
ST C4 Knowledge Discovery and Data Mining {ST 6 (T), ST 9 (T)}
ST C5 Statistical Pattern Recognition {ST 6 (T), ST 9 (T)}

The Head of the Department may decide not to offer modules if sufficient faculty is not available**.**

b) Optional papers: A student may choose optional courses from the following list or from the courses which are listed as compulsory for a module other than the module allotted to her/him or from courses offered by other Departments subject to the approval of the Head of the Department. A student may opt for a project (or two projects) in lieu of an optional (or two optional courses), as described earlier**.**

List of Proposed Optional Courses

ST E01 Stochastic Models {ST 3 (T), ST 10 (T), ST 13}

ST E02 Queues and Inventories {ST 10 (T), ST 13}

ST E03 Empirical Processes {ST 10 (T), ST 6}

ST E04 Testing of hypotheses {ST 8}

ST E05 Sequential Analysis {ST 8}

ST E06 Nonparametric Inference {ST 8}

ST E07 Discrete Data Analysis {ST 11 (T)}

ST E8 Demography {ST 3 (T), ST 8}

ST E9 Quantitative Epidemiology {ST 3 (T), ST 10 (T), ST 13}

ST E10 Advanced Time Series {ST I4}

ST E11 Statistics in Micro-array data analysis {ST 9}

ST E12 Data Mining {ST 7, ST 9}

ST E13 Statistics in Natural Language Processing {ST 3(T)}

ST E14 Statistical methods for Bio-computing {ST 5, ST 10}

ST E15 Directional Data Analysis

The Head of the Department may introduce additional optional courses on recommendations of the Departmental Committee. The syllabus of the optional courses will be prepared by the concerned teacher and will be flexible to accommodate new developments in that area. Whenever such an optional course is floated, the concerned syllabus will be discussed and approved in the Departmental committee.

c) Question papers: In view of academic autonomy given to the Department, question papers are set by the teacher who teaches the course and these are moderated by a committee of experts, as indicated earlier.

ii**) Medium of instructions:** English

6) Equivalence subject/papers & transitory provision: The Head will take the decisions as and when the case arises.

7) University Terms: Time table for the beginning and end of the terms as announced by the University will be followed.

8 & 9) Subject wise detail syllabus and recommended books: Detailed syllabi, along with the list of recommended books of the compulsory courses and module specific courses are given below.

ST 1: Mathematical Analysis

Countability, supremum and infimum of sets of real numbers. Limit point of a set – open sets, closed sets etc. (will be developed through general metric space and R^n will be considered as a special case), compactness, Bolzano-Weierstrass theorem, Heine-Borel Theorem. Continuous functions, uniform continuity, absolute continuity. Sequences and series of real numbers, limit superior, limit inferior and limit of a sequence. Cauchy sequences, convergence of series, tests for convergence of series, absolute convergence, Cauchy products.

Riemann and Riemann – Stieltjes integrals, integration by parts, mean value theorem. Uniform convergence of sequences and series. Term by term differentiation and integration, applications to power series. Improper Riemann – Stieltjes integrals: Improper integrals of first and second kind for one variable. Uniform convergence of improper integrals, differentiation under the sign of integral – Leibnitz rule.

Books Recommended

1. Apostol, T. M. (1975). Mathematical Analysis: A Modern Approach to Advanced Calculus. (Addison - Wesley)
2. Bartle, R. G. (1976). Elements of Real Analysis (John Wiley)
3. Rudin, W. (1985). Principles of Mathematical Analysis (McGraw - Hill)

ST 2(T): Linear Algebra

Matrix algebra, special types of matrices, determinants and their simple properties. Orthogonal and idempotent matrices: Linear dependence, basis of a vector space, an orthogonal basis, Gram-Schmidt orthogonalization, projection theorem, linear transformation, rank of matrix, linear equations, solution space and null space. Characteristic roots of real matrices, right and left characteristic vectors, independence of characteristic vectors corresponding to distinct characteristic roots, algebraic and geometric multiplicities; Generalized inverse, Spectral decomposition theorem.

Definiteness of a real quadratic form, reduction of quadratic forms, simultaneous reduction of two quadratic forms, maxima and minima of ratios of two quadratic forms.

Books Recommended

1. Graybill, F.E.(1961). Introduction to Matrices with Applications in Statistics (Wadsworth Pub. Co.)
2. Hohn, F. E. (1973). Elements of Matrix Algebra (Macmillan)
3. Rao, C. R. (1995). Linear Statistical Inference and Its Applications. (Wiley Eastern)
4. Searle, S. R. (1982). Matrix Algebra Useful for Statistics. (John Wiley)

Additional Books for Reference

1. Bellman, R. (1970). Introduction to Matrix Analysis (Tata McGraw Hill)

ST 2(P)

The following practicals are to be done by using the software R/SYSTAT/Matlab.

1. Calculation of determinant (4 x 4)
2. Calculation of eigen values, eigen vectors, g- inverse
3. Solution of simultaneous equations
4. Quadratic forms

ST 3(T): Probability Distributions

Random Experiment and its sample space, random variables, c.d.f., p.d.f., p.m.f., absolutely continuous and discrete distributions, mixtures of probability distributions. Some common distributions. Transformations, moments, m.g.f., p.g.f., quantiles and symmetry. Random vectors, joint distributions, joint m.g.f. mixed

moments, variance covariance matrix. Hazard rate and cumulative hazard rate, lack of memory property. IFR, IFRA, DFR and DFRA classes of distribution.

Independence, sums of independent random variables, convolutions, conditional expectation and variances, regression function and best linear regression function, multiple and partial correlation coefficients.

Sampling distributions of statistics from univariate normal random samples, such as linear and quadratic forms. Fisher Cochran theorem. Non-central chi-square, t and F distributions.

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

Probability Integral Transformation, Rank orders and their exact null distributions. One and two sample examples of rank statistic such as sign statistic, Wilcoxon signed rank statistic, Wilcoxon two sample statistic etc. Recurrence relations for the null distribution of the Wilcoxon two sample statistic.

Books Recommended

1. Hogg, R. V. and Craig, T. T. (1978). Introduction to Mathematical Statistics (Fourth Edition) (Collier-McMillan)
2. Rohatgi, V. K. (1988). Introduction to Probability Theory and Mathematical Statistics (Wiley Eastern)
3. C. R. Rao (1995). Linear Statistical Inference and Its Applications (Wiley Eastern) Second Edition
4. H, Cramer (1946). Mathematical Methods of Statistics,(Prinecton).
5. J. D. Gibbons & S. Chakraborti (1992). Nonparametric statistical Inference (Third Edition) Marcel Dekker, New York
6. W.J.Conover. (1999). Practical Nonparametric Statistics, Wiley. 3rd Edition
7. Barlow R. E. & Proschan F. (1975). Statistical Theory of Reliability & Life testing. Holt, Rinehart & Winston Inc.

ST 3(P)

Using software packages: SYSTAT, R and MINITAB

1. Plotting of density functions, distribution functions and failure rates.
2. Wilcoxon test, Wilcoxon signed-rank test, Kruskal Wallis test., rank correlation
3. Model sampling from standard distributions and mixtures of distributions.

ST 4: Multi-dimensional Calculus

Review of calculus of one variable: differentiability, mean value theorem and Taylor series expansion. Functions of several variables: Continuity, directional derivatives, differential of functions of one variable, differentials of functions of several variables, the gradient vector, differentials of composite functions and the chain rule, the mean value theorem, a sufficient condition for the existence of the differential, partial derivatives of higher order and Taylor's formula.

Multiple Integrals and evaluation of multiple integrals by repeated integration. Mean value theorem for multiple integrals.

Applications of partial differentiation: Jacobians, the inverse function theorem, the implicit function theorem, extremum problems.

Books Recommended

1. Apostol T.M. (1975). Mathematical Analysis: A modern approach to advanced calculus, (Addison-Wesley).
2. Bartle, R. G. (1976). Elements of Real Analysis (John Wiley)
3. Kreyszig, E. (1975). Advanced Engineering Mathematics (Wiley Eastern)
4. Rudin, W. (1985). Principles of Mathematical Analysis (McGraw-Hill)

5 Williamson R.E. and Tratter H.F. (1996) Multivariable Mathematics , 3rd Ed. (Prentice Hall)

ST 5(T): Numerical Analysis and Programming

Solutions to Non linear equations: Bisection method, NR. Steepest descent, Quadrature interpolation, Jacobi and Gauss Seidel Methods. Simple Optimization method. Direct search, grid search, Hooke & Jeeve's method Interpolatory search, Gradient search. Progamming in R. Random number generation methods

i. Mixed congruential
ii. Multiplicative congruential
iii. Rejection
iv. Distribution specific methods

Testing for randomness of a sequence. Runs test, digit frequency test, gap test, serial correlation
Methods to compute integrals: quadrature formula, Monte Carlo Methods. Applications of Monte Carlo methods to compute expected values of random variables..

Books Recommended:

1. Thisted R. A.(1988). Elements of Statistical Computing, (Chapman and Hall)
2. Kennedy W. J. & Gentle J. E. (1980). Statistical Computing (Marcel Dekker)
3. Rajaraman V. (1993). Computer Oriented Numerical Methods, 4th ed. (Prentice-Hall).
4. Krishnamurthy V. & Sen (1993). Numerical Algorithm Computation in Science and Engineering 2nd Ed. (Affiliated East West Press)
5. Ross, S. (2000). Introduction to Probability Models.(Academic Press)
6. Ripley B. D.(1987) Stochastic Simulation (John Wiley)

ST 5(P)

Elementary Statistics as listed below using software packages : SYSTAT, R and MINITAB.
Calculation of summary statistics (mean, median, maximum, minimum, s.d.)
Calculation of regression and correlation coefficients.
ANOVA for one-way and two way models
Analysis of 2 x 2 contingency table.
Computation of integrals by Riemann & RS sums.
Calculation of p-value for standard normal distribution (for given Z value)
Preparing frequency distribution of given data.
Calculation of double integrals.
Obtaining SRSWOR from a finite population,
Calculation of order statistic
Plotting of curves (standard & non standard)
Limits of functions
Box Plot
Computing integrals by statistical methods
Computing expectations of complicated functions, mean and variance of estimates
Calculation of empirical power & level of significance.
Empirical confidence coefficient of a confidence interval
Test for Randomness

Books Recommended:

1. Thisted R. A.(1988). Elements of Statistical Computing, (Chapman and Hall)
2. Kennedy W. J. & Gentle J. E. (1980). Statistical Computing (Marcel Dekker)
3. Rajaraman V. (1993). Computer Oriented Numerical Methods, 4th ed. (Prentice-Hall).
4. Krishnamurthy V. & Sen (1993). Numerical Agorithm Computation in Science and Engineering 2nd Ed. (Affiliated East West Press)
5. Ross, S. (2000). Introduction to Probability Models.(Academic Press)
6. Ripley B. D. (1987). Stochastic Simulation (Wiley)

7. Boswell, M.T., Gore, S.D., Patil G. P. and Tallie C. (1993). Handbook of Statistics - Vol 4 (The Art of Computer Generation of Random Variables):

ST 6: Probability Theory

Algebra of sets, fields and sigma-fields, limit of sequences of subsets, sigma-field generated by a class of subsets, Borel fields. Probability measure on a sigma-field, probability space, continuity of a probability measure, real and vector-valued random variables (r.v.s), distribution functions (d.f.), discrete r.v.s, r.v.s of the continuous type, decomposition of a d.f.

Expectation of a real r.v. and of a complex-valued r.v. Linear properties of expectations.
Characteristic functions, their simple properties, uniqueness theorem.

Convergence of a sequence of r.v.s., convergence in distribution, convergence in probability, almost sure convergence and convergence in quadratic mean and , their inter-relations. Cramer's theorem on composition of convergence in distribution and convergence in probability. Slutkey's theorem. Monotone convergence theorem and dominated convergence theorem.

Independence of two events and n (> 2) events, sequence of independent events, independent classes of events, π-system and λ-system of events, Dynkin's theorem, independence of r.v.s, Borel zero-one law.

Khintchin's weak law of large numbers, Kolmogorov strong law of large numbers (without proof), continuity theorem for characteristic functions. Lindeberg's CLT and its particular cases,

Books Recommended

1. Bhat, B. R. (1985). Modern Probability Theory (New Age International)
2. Billingsley, P. (1986). Probability and Measure (John Wiley)

Additional Books for Reference

1. Feller, W. (1969). Introduction to Probability and its Applications vol.II (Wiley Eastern Ltd.)
2. Loeve, M. (1978). Probability Theory (4th Edn) (Springer Verlag)
3. Gnedenko, B.V. (1988). Probability Theory (Mir.Pub.)

ST 7(T): Regression Analysis

Simple regression with one independent variable(X), assumptions, estimation of parameters, standard error of estimator, testing of hypothesis about regression parameters, standard error of prediction. Testing of hypotheses about parallelism, equality of intercepts, congruence. Extrapolation, optimal choice of X. Diagnostic checks and correction: graphical techniques, tests for normality, uncorrelatedness, homoscedasticity, lack of fit, modifications like polynomial regression, transformations on Y or X, WLS. Inverse regression X(Y).

Multiple regression: Standard Gauss Markov Setup. Least square(LS) estimation, Error and estimation spaces. Variance- Covariance of LS estimators. Estimation of error variance, case with correlated observations. LS estimation with restriction on parameters. Simultaneous estimation of linear parametric functions. Test of Hypotheses for one and more than one linear parametric functions. Confidence intervals and regions. ANOVA.

Non Linear regression (NLS) : Linearization transforms, their use & limitations, examination of non linearity, initial estimates, iterative procedures for NLS, grid search, Newton- Raphson , steepest descent, Marquardt's methods.

Logistic Regression: Logit transform, ML estimation. Tests of hypotheses, Wald test, LR test, score test. Test for overall regression. Multiple logistic regression, forward, backward method. Interpretation of parameters relation with categorical data analysis.

Generalized Linear model: link functions such as Poisson, binomial, inverse binomial, inverse Gaussian, gamma.

Books Recommended:

1. Draper, N. R. and Smith, H(1998). Applied Regression Analysis, 3rd Ed. (John Wiley).
2. McCullagh, P and Nelder, J. A. (1989). Generalized Linear Models. (Chapman & Hall).
3. Ratkowsky, D.A. (1983). Nonlinear Regression Modelling (Marcel Dekker).
4. Hosmer, D.W. and Lemeshow, S. (1989). Applied Logistic Regression (John Wiley).
5. Seber, G.E.F. and Wild, C.J. (1989). Nonlinear Regression (Wiley)
6. Neter, J., Wasserman, W. and Kutner,M.H. (1985). Applied Linear Statistical Models.
7. Montgomery, Douglas C.; Peck, Elizabeth A.; Vining, G. Geoffrey (2003). Introduction to Linear Regression Analysis. (Wiley)

ST 7(P)

Simple regression, regression diagnostics. (2 practicals)
Multiple regression, forward method, backward method (2 practicals)
Non-linear regression – some non-standard models (2 practicals)
Logistic regression (2 practicals)
Following practicals are to be done with the help of a software package available in the Department.
1. Best subset selection, (2) GLM, (3) Linearization techniques in non-linear models.

ST 8: Parametric Inference

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

Test function, Neyman- Pearson lemma for test functions. Uniformly most powerful tests for one sided alternative for one parameter exponential class of densities and extension to the distributions having monotone likelihood ratio property.

Confidence Intervals, shortest expected length confidence intervals, relations with testing of hypotheses, uniformly most accurate confidence intervals.

Bayesian estimation, prior distributions, posterior distribution, loss function, principle of minimum expected posterior loss, quadratic and other common loss functions, conjugate prior distributions. Common examples. Bayesian HPD confidence intervals.

Books Recommended:

1. Kale, B.K. (2005). A First Course on Parametric Inference. Second Edition. (Narosa).
2. Casella G. and Berger R. L. (2002). Statistical Inference. 2nd Edition, Duxbury Advanced series.
3. Dudewicz, E. J. and Mishra, S.N.(1988). Modern Mathematical Statistics, (John Wiley)
4. Roussas, G. G. (1973). First Course in Mathematical Statistics (Addison Wesley)
5. Silvey, S. D. (1975). Statistical Inference (Chapman and Hall)
6. Wilks, S. S. (1962). Mathematical Statistics (John Wiley)
7. Lehmann, E. L. (1986). Testing of Statistical hypothesis (John Wiley)
8. Lehmann, E. L. (1988). Theory of Point Estimation (John Wiley)
9. Rohatgi, V. K. (1976). Introduction to theory of probability and Mathematical Statistics (John Wiley & Sons)
10. Berger, J.O. (1985). Statistical Decision Theory and Bayesian Analysis, (Second Edition) Springer – Verlag
11. Ferguson, T.S. (1967). Mathematical Statistics : A Decision Theoretic Approach. Academic Press.

ST 9(T): Multivariate Analysis

Multivariate normal distribution, pdf and mgf, singular and nonsingular normal distributions, distribution of a linear form and a quadratic form of normal variables, marginal and conditional distributions. Multiple regression and multiple and partial correlation coefficients, Definition and relationships.

MLE's of the parameters of multivariate normal distribution and their sampling distributions (including derivation of Wishart distribution) Properties of the Wishart Distribution. Tests of hypothesis about the mean vector of a multinormal population, Hotelling's T^2 -statistic and its distribution. Rao's U -statistic and its distribution, Applications of Hotelling's T^2 -statistic.

Introduction to Principle Components , Canonical correlation coefficients, and canonical variables.

Cluster Analysis.

Classification problem. Discriminant analysis, Mahalanobis D^2-statistic.Methods and applications of MANOVA (without derivation of the distribution of Wilks' lambda) .

Books Recommended :

1. Anderson, T. W. (1984). Introduction to Multivariate Analysis (John Wiley)
2. Kshirsagar, A. M. (1983). Multivariate Analysis (Marcel Dekker)
3. Morrison, D.F.(1990). Multivariate Statistical Methods (McGraw Hill Co.)(3rd ed.)
4. Rao, C. R. (1995). Linear Statistical Inference and its Applications. (Wiley Eastern)
5. Johnson R.A. & Wichern, D.W. (1988). Applied Multivariate Statistical Analysis (Prentice Hall Inc.)

ST 9 (P)

1. Model Sampling from multivariate normal distribution
2. Applications of Hotelling's T^2 (2 practicals)
3. MANOVA
4. Discriminant Analysis
5. Principal Component Analysis
6. Cannonical Correlations
7. Cluster Analysis

ST 10: Stochastic Processes I

Markov chains with stationary transition probabilities, properties of transition functions, classification of states, Stationary distribution of a Markov chain, existence and uniqueness, convergence to the stationary distribution. Methods based on Markov chains for simulation of random vectors. MCMC algorithm.

Gambler's ruin problem, Transient states. Estimation of transition probabilities. Numerical Illustrations and calculations of transition probabilities.

Branching processes.

Introduction to Wiener Process and Brownian Motion.

Books Recommended

1. Taylor, H. M. and Karlin, S. (1984). An Introduction to Stochastic Modelling. (Academic Press)
2. Medhi, J.(1982). Stochastic Processes (Wiley Eastern Ltd.)
3. Ross, S. (2000). Introduction to Probability Models (7th Ed.) Academic Press
4. Bhat B.R.(2000). Stochastic Models: Analysis and Applications (New Age International)

Additional Books for Reference

1. Feller, W. (1972). An Introduction to Probability Theory and its Applications, Vol.1 3rd rd. (Wiley Eastern)
2. Karlin, S and Taylor, H. M. (1969). A First Course in Stochastic Processes (Second.Edition) Academic Press
3. Hoel, P. G. Port, S.C. and Stone, C. J. (1972). Introduction to Stochastic Processes (Houghton Mifflin)

ST 11(T): Asymptotic Inference

Consistency and asymptotic normality (CAN) of real and vector parameters. Invariance of consistency under continuous transformation. Invariance of CAN estimators under differentiable transformations, generation of CAN estimators using central limit theorem. Method of moments, method of maximum likelihood, Special cases such as exponential class of densities and multinomial distribution, Cramer-Huzurbazar theorem, method of scoring.

Tests based on MLEs. Likelihood ratio tests, asymptotic distribution of log likelihood ratio, Wald Test, Score Test, locally most powerful tests. Applications to categorical data analysis, three dimensional contingency tables, Pearson's chi-square test and LR test. Asymptotic comparison of tests. Asymptotic Relative Efficiency (Pitman's), asymptotic normality of posterior distributions.

Books Recommended:

1. Kale B.K. (2005). A First Course on Parametric Inference. Second Edition. (Narosa)
2. Cramer, H.(1974). Mathematical Methods in Statistics (Princeton Univ. Press)
3. Rao, C. R.(1995). Linear Statistical Inference and its Applications (Wiley Eastern Ltd).
4. Silvey, S. D.(1975). Statistical Inference (Chapman- Hall)
5. Wilks, S.S.(1962). Mathematical Statistics (John Wiley)
6. Ferguson, T.S. (1996). A Course in Large Sample Theory (Chapman and Hall)

ST 11 (P)

1. Estimation of parameters of mixture distributions.
2. Functional estimation using kernels, bandwidth selection
3. Verification of consistency and asymptotic normality of estimates
4. Maximum likelihood estimation under various set up (includes censoring situations)
5. Comparing methods of estimation, MSE and sample size considerations
6. Power functions and comparison of tests (LR, WALD, RAO)
7. Analysis of higher dimensional contingency tables.

ST – 12(T): Design of experiments and Analysis of Variance

Randomization, replication, local control, one way and two way classification with unequal and equal number of observations per cell (with / without interactions). Connectedness, balance, orthogonality, BIBD, ANOCOVA.

2^k full factorial experiments: diagrammatic presentation of main effects and first order interactions, model, analysis of single as well as more than one replicates, using ANOVA.

Total confounding of 2^k design in 2^p blocks, $p \geq 2$. Partial confounding in 2^p blocks, $p = 2, 3$. Fractional factorial experiments. Resolution of a design, (III, IV & V), aberration of a design.

Concept of rotatable design. Central composite designs, 3^2 designs: contrasts for linear and quadratic effects, statistical analysis of 3^2 design.

Response surface methodology (RSM): linear and quadratic model, stationary point, ridge systems,

multiple responses, blocking in RSM.

Taguchi (orthogonal array) methods: concept of loss function, S/N ratio, linear graphs, ANOM, inner and outer arrays. ANOVA.

Random effect models for one way classification.

Books Recommended:

1. Kshirsagar A.M. (1983). Linear Models (Marcel Dekker)
2. John P.W.M.(1971). Linear Models (John Wiley Ltd.)
3. Montgomery, D.C. (2001). Design and Analysis of Experiments (John Wiley)
4. Ogawa J. (1974). Statistical Theory of the Analysis of Experimental Design (Marcel Dekker)

ST 12(P): Design of experiments and Analysis of Variance

1. One way classification. Multiple comparison tests.
2. Two way classification with equal / unequal number of observations per cell (model with interaction).
3. LSD and BIBD.
4. Analysis of covariance in one way and two way data.
5. 2^n Factorial Experiments, Analysis of Single Replicate of 2^n.
6. Total and partial confounding for n = 2,3,4,5.
7. Fractional Replication.
8. 3^2 Factorial Experiments.
9. Fitting first and second order response surface model. Central Composite Design, Contour, surface plots

ST 13: Stochastic Processes II

Markov pure jump processes, Poisson process, Birth and Death processes. Finite state continuous time Markov chains.

Renewal processes, Poisson process as a renewal process, elementary renewal theorem. Statement (without proof) of other renewal theorems.

Simple queueing systems.

Books Recommended

1. Taylor, H. M. and Karlin, S. (1984). An Introduction to Stochastic Modelling. (Academic Press)
2. Medhi, J.(1982). Stochastic Processes (Wiley Eastern)
3. Ross, S. (2000). Introduction to Probability Models (7^{th} Ed.) Academic Press
4. Bhat B.R.(2000). Stochastic Models: Analysis and Applications (New Age International)

ST 14(T): Sampling Methods

Basic methods of sample selection, simple random sampling with replacement (SRSWR), simple random sampling without replacement (SRSWOR), probability proportional sampling with and without replacement, systematic sampling, estimation problems, Horwitz- Thompson estimator and its properties.

Stratification: Allocation problems and estimation problems, formation of strata and number of strata, method of collapsed strata.

Use of supplementary information for estimation, ratio and regression estimators with their properties and generalizations, Jackknife methods.
Cluster sampling, multistage-sampling. Double sampling procedures, Ratio and regression estimators, stratification.

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

Books Recommended

1. Des Raj and Chandhok, P. (1998). Sample Survey Theory (Narosa)
2. Sukhatme P.V, Suktatme, B.V., Sukhatme S. and Asok C. (1984). Sampling Theory of Surveys with Applications (Indian Soc. for Agricultural Statistics, New Delhi).
3. Cochran, W.G. (1984). Sampling Techniques (Wiley)

Additional Books for Reference

Murthy, M.N. (1977). Sampling Theory and Methods

ST 14(P): Sampling Methods

SRSWOR, SRSWR, Stratified random sampling, various kinds of allocation, Post stratification, using auxiliary information.

Ratio and regression methods of estimation, pps sampling design.

Double sampling, two stage sampling, Systematic sampling, cluster sampling Randomized response technique.

Two practicals of consolidated nature each one of which would use theory of one or more of the above topics.

ST 15(P) Practicals (Projects)

The course consists of following two components - (i) Summary of research articles and
(ii) Data Analysis

Summary of Research Articles

Students are expected to read some articles (number will be decided by the supervisor) on a specified topic or theme, summarize and write a comprehensive report and present the summary of the articles.

Data Analysis

Students are expected to choose her/his own project, wherein they are expected to analyze data pertaining to certain theme using a variety of statistical tools that they have studied so far.

This completes the detailed syllabi of 15 compulsory courses. Syllabi of module specific courses follow.

Module 1: Probability and Mathematical Statistics

ST P1: Measure Theory and Probability

Ring, σ-ring, Measure, Measure space, Caratheodory Extension theorem, Lebesgue measure.

Integral of a measurable function with respect to a measure, its properties. Hahn – Jordan decomposition, Lebesgue decomposition, Radon – Nikodym derivative.

Product measure, Fubini's theorem. Convergence in measure, almost everywhere convergence, Kolmogorov Inequality. Kolmogorov three series criterion strong law of large numbers, conditional

Probability and conditional expectations, their simple properties. Martingales martingale convergence theorems (SLLN, CLT)

Books Recommended

1. Billingsley, P. (1986). Probability and Measure (John Wiley)
2. Ash, R.B. (1972). Real Analysis and Probability (Academic Press)
3. Kingman and Taylor (1968). Introduction to Measure and Probability (Cambridge Univ.Press)
4. Athreya, K.B. and Lahiri, S.N. (2006). Measure Theory and Probability Theory (Springer)
5. Williams, P. ( ) Probability and Martingales

Additional Books for Reference

1. Halmos, P. R. (1962).Measure Theory

ST P2: Advanced Stochastic Processes

Markov Chains: Taboo Probabilities and Ratio Limit Theorems. Invariant measures: [1]. ch. 11, Sections 1-4.
Markov Sequences: Definitions, Transition Densities, Stationary Distribution, Normal Markov Sequences [2] Ch. VI Section 11, ch. III Section 8 Markov Pure jump processes [4], [1]. Stochastic Processes (General Theory) : Probability spaces appropriate for stochastic processes, Kolmogorov's extension theorem. (only sketch of the proof), separability, progressive measurability and strong Markov property of stochastic processes [3], Ch. 4 Sections 1 and 2.

Diffusion Processes : Definition, Elementary properties, infinitesimal parameters, standard process and Dynkin's theorem, Continuity and non-differentiability of Diffusion processes. Modeling based on Diffusion processes, Standard Brownian Motion, Ornstein-Ulhenbeck process and other processes, Transformation of processes, Distribution of Hitting times and related problems,
scale function and speed density, Kolmogorov's backward differential equations, forward differential equations (without proof), transition density and stationary distribution of a diffusion process.

Books Recommended

1. Karlin, S. and Taylor H.M. (1981) A Second course in Stochastic Processes (Academic Press)
2. Feller, W. (1969) An Introduction to Probability Theory. (Vol.II)
3. Ash, R.B. and Gardner M.F.(1975), Topics in Stochastic Processes (Academic Press)
4. Adke, S.R. & Manjunath S.M. (1984) Finite Markov Processes (John Wiley and Sons)
5. Athreya & Lahiri ( )

ST P3 : Decision Theory and Bayesian Analysis

Formulation of a decision problem : randomized and non-randomized decision rules, risk function, optimality of decision rules. Utility theory and loss function.

Subjective probability and selection of prior distribution for Bayesian analysis. Bayesian analysis for statistical inference problems of estimation, testing hypotheses, confidence interval and prediction. Bayesian decision theory. Admissible and minimax decision rules. Complete class of decision rules.

Books Recommended

1. James O. Berger (1985), Statistical Decision Theory and Bayesian Analysis ,

(Second Edn.) Springer -Verlag

(Specific material to be covered is in the following sections of the book 1, 2.1, 2.2, 2.4.1, 2.4.2, 3.1-3.3, 4.1-4.4.3, 4.8, 5.1-5.3, 8.1,8.2.)

Additional Books for Reference

1. DeGroot M. H. (1970) Optimal Statistical Decisions

2. Ferguson, T.S. (1967) Mathematical Statistics : A Decision Theoretic Approach. Academic Press.

ST P4 : Advanced Multivariate Analysis

Canonical variables, canonical correlation coefficients, and canonical vectors, Distributions of the sample canonical correlations coefficients and canonical vectors.

Wilk's Λ Criterion. The distribution of Wilk's \Lambda criterion. Tests based on Wilk's Λ. Alternatives to Wilk's Λ criterion.

Multivariate analysis of variance. Discrimination in case of several groups.

Application of Wilk's Λ and canonical analysis in contingency tables. Likelihood ratio tests concerning mean vectors and covariance matrices of several populations, their properties. Principal components distributions associated with sample principal components (Null case). James Stein estimator of population mean vector.

Factor Analysis.

Books Recommended

1. Anderson, T. W. (1984) Introduction to Multivariate Statistical Analysis, John Wiley
2. Kshirsagar, A.M.(1983) Multivariate Analysis, Marcel Dekker
3. Rao, C. R.(1995) Linear Statistical Inference and its Applications, John Wiley.

ST P5 Inference in Stochastic Processes

Inference in Markov chains, estimation of transition probabilities, testing for order of a Markov chain, estimation of functions of transition probabilities, parametric models and their goodness of fit.
Markov sequences, estimation of paramaters based on likelihood and conditional least squares, auto-regressive series. Models for higher order Markov chains.(Raftery)

Statement of martingale strong law of large numbers and CLT for martingales, CAN property of the mle from a general sequence of dependent random variables, Fisher information. Applications to Markov chains and sequences.

Likelihood of Poisson and other Pure Jump Markov processes from first principles, CAN property of mles , testing for a Poisson process, non-homogeneous processes, Analysis of parametric Pure Jump processes, Birth-Death-Immigration processes, testing goodness of fit of such models

Diffusion processes and their likelihood, properties of estimators (without proof)

Branching processes, Inconsistency of mle/moment estimators, Properties of estimators on the non-extinction path, Asymptotic distribution theory.
Elements of semi-parametric and non-parametric analysis, Theory and applications of optimal estimating functions, estimation of transition and stationary density, intensity function of a counting process.

Methods based on estimating functions, panel data, introduction to spatial models.

Books Recommended:

1. Billingsley, P. (1962) Statistical Inference for Markov chains, (Chicago University Press).

2. Basawa, I.V. and Prakasa Rao, B.L.S.(1980) Statistical Inference for Stochastic Processes , (Academic Press).
3. Adke, S.R. and Manjunath, S.M.(1984) An introduction to Finite Markov Processes, (Wiley Eastern).
4. Guttorp, P. (1991) Statistical Inference for Branching Processes, (Wiley).
5. Guttorp, P.(1995) Stochastic Modelling for Scientific Data, (Springer).
6. Bhat B.R.(2000) Stochastic Models: Analysis and Applications (New Age International)
7. Prakasa Rao, B.L.S. and Bhat, B.R.(1996) Stochastic Processes and Statistical Inference, New Age International.
8. Davison, A. C. (2003) Statistical Models Cambridge Univ. Press.

Module 2: Industrial and Financial Statistics

ST-I1 (Optimization Techniques)

Linear Programming: Convex sets, Supporting and Separating Hyper-planes, Standard linear Programming Problem, basic feasible solution, simplex algorithm and simplex method, graphical solution, two phase method. Duality in linear programming, duality theorems, dual simplex method with justification, sensitivity.

Transportation and assignment algorithms, Hungarian method of assignment, transshipment problems, duality theory of testing optimality of solution in transportation problem and transshipment problems, transportation problem and transshipment problems as network problems Balance and degeneracy in transportation problem.

Maximization, prohibitions and other variations of assignment problems. Integer linear Programming Problem, branch and bound method, Network flows, maximal flow in the network.
Nonlinear Programming: Kuhn-Tucker conditions, Quadratic programming,Wolfe's, Beale's and Fletcher's algorithms for solving quadratic programming problems.

Markovian and Non-Markovian queueing models, cost profit models of (M/M/1) and (M/M/s) queueing systems. Simulation, event type simulation, simulation of a queuing systems.
Dynamic programming

Books Recommended:

1. Kambo, N.S. (1991) Mathematical Programming Techniques (Affiliated Eas-west press Pvt. Ltd.)
2. Hadley, G. (1987) Linear Programming.
3. Taha, H.A. (1992) Operations Research 5th ed. (Macmillan)
4. Panneerselvam, R. Operations Research (Prentic hall of India)
5. Medhi j. (1984) Stochastic Processes 2nd ed.(New Age International Pvt. Ltd.)

ST I2: Statistical Methods for Quality

Total Quality Management: Concept of Quality, Quality improvement, Quality philosophy, Introduction of TQM, Evaluation of Total Quality, Some important TQM concepts, TQM Gurus' Ideas, Japanese 5-S Practice, The Impact of National and International Quality Awards on TQM, The European Quality Award, The Deming Application Prize, Six sigma and other Extensions of TQM, Quality systems, The ISO 9000 and other Quality systems.

Statistical Process Control: concepts of stable industrial processes, Systematic variation, random variation. SPC, variable & attribute control charts, X-R, X-MR, C, U, nP, P, CUSUM, EWMA charts. Comparison of shewhart control charts with CUSUM charts General ideas on economic designing of control charts. Duncan's model for the economic control chart. Process capability & performance indices,

C_p, C_{pk}. Estimation & confidence intervals for estimators of C_p. Connection between proportion of defectives & C_p.

Acceptance Sampling plans: Single, double & multiple sampling plans for attributes. Curtailed double sampling plans. Operating characteristic functions & other properties of the sampling plan. Use of sampling plans for rectification. Dodge-Romig acceptance sampling plans.

Acceptance sampling plan for variables. Designing variable acceptance sampling plans. AQL based sampling plans. Continuous sampling plans CSP-I & CSP – II.

Books Recommended:

1. Montgomery, D. C. (1985) Introduction to Statistical Quality Control.(Wiley)
2. Besterfield, D.H., Besterfield-Michana, c., Besterfield, G.H., Besterfield-Sacre, M. (2001): Total Quality Management; Pearson Education(Singapore) Pte. Ltd. India. 2nd Edition.
3. Logothetis, N.(1992). Managing Total Quality; Prentice Hall of India.

4. Oakland J.S. (1989). Total Quality Management; Butterworth-Heinemann.

ST I3 : Survival Analysis

Concepts of Time, Order and Random Censoring.

Life distributions - Exponential Gamma, Weibull, Lognormal, Pareto, Linear Failure rate. Parametric inference Point estimation, Confidence Intervals, Scores, tests based on LR , MLE

Life tables, Failure rate, mean residual life and their elementary properties. Ageing classes - IFR, IFRA, NBU, NBUE, HNBUE and their duals, Bathtub Failure rate.

Estimation of survival function - Actuarial Estimator, Kaplan - Meier Estimator, Estimation under the assumption of IFR/DFR.

Tests of exponentiality against non-parametric classes - Total time on test, Deshpande test. Two sample problem - Gehan Test, Log rank test. Mantel - Haenszel Test, Tarone - Ware tests.

Semi-parametric regression for failure rate - Cox's proportional hazards model with one and several covariates.

Books Recommended:

1. Cox, D.R. and Oakes, D. (1984) Analysis of Survival Data, Chapman and Hall, New York.
2. Gross A.J. and Clark, V. A. (1975) Survival Distributions: Reliability Applications in the Biomedical Sciences, John Wiley and Sons.
3. Elandt - Johnson, R.E. Johnson N.L. (1980) Survival models and Data Analysis, John Wiley and Sons
4. Miller, R.G. (1981) Survival Analysis (Wiley)
5. Zacks, S. Reliability

ST I4: Time Series Analysis

Time-series as discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties.

Exploratory time Series Analysis, Tests for trend and seasonality. Exponential and Moving average smoothing. Hot -Wiinters smoothing. Forecasting based on smoothing, adaptive smoothing.

Detailed study of the stationary processes: (1) moving average (MA), (2) Auto regressive (AR), (3) ARMA and (4) AR integrated MA (ARIMA) models. Box-Jenkins models. Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory. Choice of AR

and MA periods. Estimation of ARIMA models parameters. Forecasting. Residual analysis and diagnostic checking.

Introduction to spectral analysis of weakly stationary process. Periodogram and correlogram analyses.

Nonstationary and Seasonal Time series Models: Unit-root nonstationarity, Unit-root tests, Integrated ARMA (ARIMA) models, Seasonal ARIMA (SARIMA) models
Conditional Heteroschedastic Models: Volatility models, ARCH and GARCH, Properties, Examples, Estimation & Forecasting,
Multivariate Time series model, VAR models, Vector ARMA models, Cointegration models.
Use of statistical software for time series analysis

Books Recommended:

1. Box, G. E. P. and Jenkins, G. M. (1976). Time Series Analysis – Forecasting and Control, Holden-day, San Franciscor.
2. Anderson, T. W. (1971). The Statistical Analysis of Time Series, Wiley, N.Y.
3. Montgomery, D. C. and Johnson, L. A. (1977). Forecasting and Time Series Analysis, McGraw Hill.
4. Kendall, Sir Maurice and Ord, J. K. (1990). Time Series (Third Edition), Edward Arnold.
5. Brockwell, P.J. and Davis, R. A. Time Series: Theory and Methods (second Edition). Springer – Verlag.

Additional Books for Reference:

1. Fuller, W. A. (1976). Introduction to Statistical Time Series, John Wiley, N. Y.
2. Granger, C. W. J. and Newbold (1984). Forecasting Econometric Time Series, Third Edition, Academic Press.
3. Priestley, M. B. (1981). Spectral Analysis & Time Series, Griffin, London.
4. Bloomfield, P. (1976). Fourier Analysis of Time Series – An Introduction, Wiley.
5. Granger, C. W. J. and Hatanka, M. (1964). Spectral Analysis of Economic Time Series, Princeton University Press, N. J.
6. Koopmans, L. H. (1974). The Spectral Analysis of Time Series, Academic Press.
7. Nelson, C. R. (1973). Applied Time Series for Managerial Forecasting, Holden-Day.
8. Findley, D. F. (Ed.) (1981). Applied Time Series Analysis II, Academic Press.

ST I5: Actuarial Statistics

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

Life insurance: Insurance payable at the moment's of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance.

Life annuities: Continuous life annuities, discrete life annuities, life annuities with monthly payments.

Net premiums: Continuous and discrete premiums, true monthly payment premiums.
Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses.

Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi continuous basis, reserves based on true monthly premiums

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.

Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications.

Books Recommeded:

1. N. L. Bowers, H. U. Gerber, J. C. Hickman, D. A. Jones and C. J. Nesbitt, (1986), Actuarial Mathematics', Society of Actuaries, Itasca, IIIinois, U. S. A. Second Edition (1997)
Section I – Chapters: 1, 2, 3, 8, 9, and 11
Section II – Chapters: 4, 5, 6, 7, 13, and 14
2. Deshmukh S.R. (2009) An Introduction to Actuarial Statistics Using R , Universities Press

Books for Additional References:

1. Spurgeon E. T. (1972), Life Contingencies, Cambridge University Press.
2. Neill, A. (1977). Life Contingencies, Heinemann.

ST I 6: Stochastic Models in Finance

Derivatives : forward and future contracts. Markets, prices, arbitrage and hedging. Complete market, market risk and credit risks in the use of derivatives.

Options markets, properties of stock option prices. American and European options.
Binomial model : One-step and two-step models, Binomial trees. Risk neutral valuation.

Behaviour of stock prices : Conditional expectation, Martingale, Brownian Motion and
Geometric Brownian motion, Markov property, Ito integral, Ito/diffusion and Mean-reverting processes Process, Ito Lemma.

Black Scholes model: Distribution of returns, volatility, risk neutral pricing, equivalent
martingale measure, Black-Scholes-Merton differential equation. Estimating voloatility.

Options on stock indices, currencies and futures. Some exotic equity and foreign exchange derivatives. Greek Letters and hedging. Interest rate derivatives, Black model. Models of the term structure of interest rates: one factor diffusion model, Vasicek, Cox-Ingersoll-Ross and Hull white models.

Books Recommended:

1) John Hull, (2008). Options, futures and other derivatives, (International 7th Edn), Prentice Hall.
2) M.Baxter and A.Rennie, (1996). Financial Calculus, Cambridge University Press.
3) N.Bingham and R.Keisel , (1998). Risk-Neutral Valuation, Springer.

Module 3: Bio-statistics

ST B1: Statistical Ecology

Population Dynamics: One species - exponential, logistic and Gompertz models. Two species - competition, coexistence, predator - prey oscillation, Lotka - Volterra equations, isoclines. Leslie matrix model for age structured populations. Survivorship curves - constant hazard rate, monotone hazard rate and bath-tub shaped hazard rates.

Population density estimation : Capture- recapture models, nearest neighbor models, line transect sampling.
Ecological Diversity : Simpson's index, Shannon – Weaver index, Diversity as average rarity.

Optimal Harvesting of Natural Resources, Maximum sustainable yield, tragedy of the commons.
Game theory in ecology : Concept of Evolutionarily stable strategy, its properties, simple cases such as Hawk-Dove game.
Foraging Theory : Diet choice problem, patch choice problem, mean variance tradeoff .

Books Recommended:

1. Gore A.P. and Paranjpe S.A.(2000) A Course on Mathematical and Statistical Ecology, Kluwer Academic Publishers.
2. Pielou, E.C. (1977) An Introduction to Mathematical Ecology (Wiley)
3. Seber, G.A.F. (1982) The estimation of animal abundance and related parameters 2^{nd} Ed. (C.Griffin)
4. Clark, C.W. (1976) Mathematical bio-economics: the optimal management of renewable resources (John Wiley)
5. Maynard Smith J. (1982) Evolution and the theory of games (Cambridge University Press)
6. Stephens D.W. & Krebs, J. R. (1986) Foraging Theory (Princeton University Press).

ST B2: Statistical Genetics

Gene frequency, random mating, Hardy-Weinberg Equilibrium, Matrix theory of random mating with applications.

Inbreeding, coefficients of inbreeding, inbreeding in randomly mating populations of finite size.
Statistical problems in human genetics, blood group analysis.

Natural selection.
Quantitative genetics, study of inheritance of quantitative characters in random and nonrandom mating diploid populations. Detection and estimation of linkage
.
Sequence similarity, homology and alignment. Algorithm for (a) pair wise sequence alignment, (b) multiple sequence alignment, construction of phylogenetic trees, UPGMA. Neighbor joining, maximum parsimony and maximum likelihood algorithms.

Books Recommended:

1. Li, C.C. (1972) Population Genetics (Univ. of Chicago Press)
2. Ewens, W.J. (1979) Mathematical Population Genetics (Springer Verlag)
3. Nagilaki, T. (1992) Introduction to Theoretical Population Genetics (Springer Verlag)
4. Durbin, R., Eddy, S.R., Krogh, A. and Mitchison,G. (1998) Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. (Cambridge Univ. Press)

Additional Books for Reference

1. Elandt-Johnson,R.C. (1971) Probability Models and Statistical Methods in Genetics (John Wiley)
2. Kempthorne, O. (1977) An Introduction to Genetic Statistics (Iowa State Univ.Press)
3. Crow, J.F. & Kimura, M. (1970) An Introduction to Population Genetic Theory Harper & Row, New York
4. Prem Narain (1990) Statistical Genetics, Wiley Eastern

ST B3 : Survival Analysis

Syllabus of this course is the same as that of ST I3.

ST B4: Analysis of Clinical Trials

Introduction to clinical trails: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials.

Data management: data definitions, case report forms, database design, data collection systems for good clinical practice.
Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of Phase III trials with sequential stopping, design of bio-equivalence trials.

Reporting and analysis: analysis of categorical outcomes from phase I – III trials, analysis of survival data from clinical trials.

Surrogate endpoints: selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data.
Meta-analysis of clinical trials.

Books Recommended:

1. S. Piantadosi (1997). Clinical Trials: A Methodological Perspective. Wiley and Sons.
2. C. Jennison and B. W. Turnbull (1999). Group Sequential Methods with Applications to Clinical Trails, CRC Press.
3. L. M. Friedman, C. Furburg, D. L. Demets (1998). Fundamentals of Clinical Trials, Springer Verlag.
4. J. L. Fleiss (1989). The Design and Analysis of Clinical Experiments. Wiley and Sons.
5. E. Marubeni and M. G. Valsecchi (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.

ST B 5: Actuarial Statistics

This syllabus is the same as ST I 5.

ST B6: Medical and Health Statistics

Study designs in epidemiology. Measures of disease occurrence and association, variation and bias. Identifying non-causal association and confounding.

Defining and assessing heterogeneity of effects, interaction. Sensitivity and specificity of diagnostic test, Cohort Study designs, statistical power and sample size computations.

Log-linear models, 2xK and 2x2x2 contingency tables. Logistic model. Analysis of binary data.
Cross-control study designs, matched case-control studies

Survival data : Proportional hazards model, multivariate survival data.
Causal Inference, Longitudinal data.
Communicating results of epidemiological studies, ethical issues in epidemiology.

Books Recommended:

1. Selvin : Statistical analysis of epidemiological data.
2. Diggle, Liang and Zeger : Analysis of longitudinal data
3. Piantadosi : Clinical trials
4. Agresti : Categorical Data Analysis.
5. Clayton and Hills : Statistical methods in Epidemiology
6. McCullagh and Nelder : Generalized Linear Models.
7. Brookemeyer and Gail : AIDS Epidemiology : A Quantitative Approach
8. Zhou, Obuchowski and McClish : Statistical Methods in Diagnostic Medicine

Module 4: Computational Statistics

ST C1: Statistical Simulations

Stochastic simulations: generating random variables, simulating normal, gamma and beta random variables. Comparison of algorithms to generate random variables. Generating random variables from failure rates. Simulating multivariate distributions, MCMC methods and Gibbs sampler, Simulating random fields, simulating stochastic processes.

Variance reduction techniques : importance sampling for integration, control variates and antithetic variables.

Simulating a non-homogeneous Poisson process.
Optimization using Monte Carlo methods, simulated annealing for optimization.
Solving differential equations by Monte Carlo methods.

1. Fishman, G.S. (1996) Monte Carlo: Concepts, Algorithms, and Applications. (Springer).
2. Rubinstein, R.Y. (1981); Simulation and the Monte Carlo Method. (Wiley).
3. Ripley B.D. (1987) Stochastic Simulations (Wiley)
4. Ross, S.M.(2002) Simulation (Third Edition) (Academic)

ST C2 : Computer Intensive Statistical Methods

Jackknife and Bootstrap.
Bootstrap methods: re-sampling paradigms, bias and standard errors, Bootstrapping for estimation of sampling distribution, confidence intervals, variance stabilizing transformation, bootstrapping in regression and sampling from finite populations.

Jackknife and cross-validation: jackknife in sample surveys, jack-knifing in regression with hetero-scadisticity, cross-validation for tuning parameters.

EM algorithm: applications to missing and incomplete data problems, mixture models.
Applications to Bayesian analysis. Monte Carlo EM algorithm MCMC methods in missing data.

Smoothing with kernels: density estimation, simple nonparametric regression. Failure rate.
Permutation tests

Books Recommended:

1.Fishman, G.S. (1996) Monte Carlo: Concepts, Algorithms, and Applications.(Springer).
2. Rubinstein, R.Y. (1981); Simulation and the Monte Carlo Method. (Wiley).
3. Tanner, M.A. (1996); Tools for Statistical Inference, Third edition. (Springer.)
4.Efron, B. and Tibshirani. R.J. (1993); An Introduction to the Bootstrap.
5.Davison, A.C. and Hinkley, D.V. (1997) Bootstrap methods and their applications (Chapman and Hall).
6. Shao J. and Tu, D. (1995); The Jackknife and the Bootstrap. Springer Verlag.
7. McLachlan, G.J. and Krishnan, T. (1997) The EM Algorithms and Extensions. (Wiley.)
8. Simonoff J.S. (1996) Smoothing Methods in Statistics. (Springer).
9. Kennedy W. J. & Gentle J. E. (1980) Statistical computing (Marcel Dekker)

ST C3: Advanced Computer Programming

This course is intended to introduce object-oriented computer programming. It assumes prior exposure to programming in languages such as C and/or Fortran.
The language of choice here is C++ .

Introduction to object-oriented programming concepts and design.
Programming in C++: data types and operations, functions and parameters, classes, constructors, input/output, control statements such as if-else, switch, for, while and do-while, pointers and references, dynamic allocation, processing of linked lists, arrays and character strings, libraries.

Introduction to program analysis: simple testing and debugging
Introduction to Web programming: simple examples in Java and the concept of byte code.

Note:If the previous exposure to C++ is observed then java can be substituted.

Books Recommended:
1. Decker, R and Hirshfield,S. (1998). The Object Concept: An Introduction to Computer Programming using C++. (PWS Publishing.)
2. Lippmann, S.B. and Lajoie, J. (1998). C++ Primer. Third edition. (Addison-Wesley).
3, Naughton, P. (1996). The Java Handbook. (Tata McGraw-Hill.)
4. Savitch, W.J. (2001). Problem Solving with C++: The Object of Programming. Third edition. (Addison-Wesley Longman).

ST C4: Knowledge Discovery and Data Mining

Review of classification methods from multivariate analysis, classification and decision trees. Clustering methods from both statistical and data mining viewpoints, vector quantization.

Unsupervised learning from univariate and multivariate data,
Dimension reduction and feature selection.

Supervised learning from moderate to high dimensional input spaces, artificial neural networks and extensions of regression models, regression trees.

Introduction to databases, including simple relational databases, data warehouses and introduction to online analytical data processing.

Association rules and prediction, data attributes, applications to electronic commerce.

Books Recommended:
1. Berson, A. and Smith, S.J. (1997). Data Warehousing, Data Mining, and OLAP. (McGraw-Hill.)
2. Breiman, L., Friedman, J.H., Olshen, R.A. and Stone, C.J. (1984). Classification and Regression Trees. (Wadsworth and Brooks/Cole).
3.Han,J. and Kamber.M. (2000). Data Mining; Concepts and Techniques. (Morgan Kaufmann.)
4. Mitchell, T.M. (1997). Machine Learning. (McGraw-Hill.)
5. Ripley, B.D. (1996). Pattern Recognition and Neural Networks. (Cambridge University Press).

ST C5: Statistical Pattern Recognition

Linear classifiers: linear discriminant function (LDF) for minimum squared error, LDF for binary outputs, perception learning algorithm.

Nearest neighbor decision rules: description, convergence, finite sample considerations, use of branch and bound methods.

Probability of errors: two classes, normal distributions, equal covariance matrix assumptions, Chernoff bounds and Bhattacharya distance, estimation of probability of error.

Feature selection and extraction: interclass distance measures, discriminant analysis, probabilistic distance measures, principal components.

Books Recommended:

1. Duda, R.O. and Hart, P.E. (1973). Pattern Recognition and Scene Analysis. (Wiley).
2. Fukunaga,K. (1990). Introduction to Statistical Pattern Recognition, 2nd Ed. (Academic Press).
3. McLachlan, G.J. (1992). Discriminant Analysis and Statistical Pattern Recognition. (Wiley).
4.Ripley, B.D. (1996). Pattern Recognition and Neural Networks. (Cambridge University Press).