INDIAN STATISTICAL INSTITUTE

POST-GRADUATE DIPLOMA
IN
STATISTICAL METHODS AND ANALYTICS

STUDENT BROCHURE
Effective from the Academic Year 2021-2022

POST-GRADUATE DIPLOMA IN STATISTICAL METHODS AND ANALYTICS

Contents

POST-GRADUATE DIPLOMA IN STATISTICAL METHODS AND ANALYTICS

This one year (two semester) programme is offered at Chennai Centre, Chennai and North-East Centre, Tezpur. Fifty percent seats of North-East Centre are reserved for the North-East domicile students.

I. GENERAL INFORMATION

1 Scope

The course is intended to provide students with a comprehensive and rigorous training in basic theory and applications of Statistical Methods and Analytics, in addition to some exposure to Mathematics and Computational Techniques. The students are exposed to data handling using R and Python packages. The programme is so designed that on successful completion, the students will be able to take up jobs in industries and government departments where applications of Statistics and Data Analytics are required.

2 Eligibility

In order to be eligible for admission to this programme, a candidate must have a three-year Bachelor's degree in any discipline with Mathematics as one of the subjects or a B.E./B.Tech. degree or any other qualification considered equivalent (such as A.M.I.E. diploma).
The North-East domicile students must provide a domicile certificate of North-Eastern states from a recognized authority.
Any student who is asked to discontinue the programme is not eligible for readmission in to this programme.

3 Stipend and Contingency Grant

There is no tuition fee. The North-East domicile students admitted to this programme will receive a monthly stipend of Rs 3000/- for a period of eleven months and an annual contingency/book grant of Rs 3000/-. In the first

instance, stipends will be granted for the first semester only and renewed if the progress of the student is found to be satisfactory. Stipend granted to a student may be reduced or fully withdrawn if the academic progress, attendance in class or character and conduct of the student are not found satisfactory (Further details in Section 14).
There is no stipend for the non-domicile students at Chennai and North-East Centres.

4 Selection Procedure

Selection is based on the performances in written test and interview. Past academic records may also be taken into consideration. The written test will comprise of multiple-choice questions in Mathematics and Probability at pass/minor level of Bachelor's degree.

5 Course Structure

The one-year programme consists of a total of 10 courses. There are five courses in the first semester and four courses plus a one-course project in the second semester.

Semester I	**Semester II**
1. Probability Theory	6. Statistical Methods II
2. Statistical Methods I	7. Statistical Machine Learning
3. Statistical Inference	8. Statistical Modeling
4. Vectors & Matrices and Regression Methods	9. Time Series and Statistical Finance
5. Programming: R and Python	10. Project

The project work is likely to extend through summer.
All students from North-East Centre may be required to spend one week at the headquarters of the Institute (Kolkata) at the end of Semester I.

6 Examinations and Scores

Courses 1, 2, 3, 5, 6, 7 and 8 are **Non-Module-Based** courses. Courses 4 and 9 are **Module-Based** courses, each consisting of two modules.

Non-Module-Based Courses

The final (semester) examination in a course is held at the end of the semester. Besides, there is a mid-semester examination in each course. The calendar for the semester is announced in advance. The composite score in a course is a weighted average of the scores in the mid-semester and semester examinations, class tests, homework, assignments, and/or project work in that course. The weights are announced beforehand by the Dean of Studies, or the Students' Academic Affairs In-Charge or the Class Teacher in consultation with the concerned teacher or the concerned teacher. The minimum composite score to pass a course is 35%.

Module-Based Courses

There will be one examination at the end of the module for each of the two modules for any Module-Based course. Equal weight will be given to the two modules for computing the composite score of the course. The score in a module is a weighted average of the scores in the internal assessments and the end of the module examination. For each module, the weights to be given to homework, assignments, class tests, end-module examination etc will be announced beforehand by the Dean of Studies or the Students' Academic Affairs In-Charge or the Class Teacher in consultation with the concerned teacher or the concerned teacher. The minimum composite score to pass a course is 35%.

Back-Paper Examination

For both types of courses, if the composite score of a student falls short of 45% in a course, the student may take a back-paper examination to improve the score. At most one back-paper examination is allowed in each course. Moreover, a student can take **at most two** back-paper examinations in the first semester and **at most one** in the second semester. The decision to allow a student to appear for the back-paper examination is taken by the appropriate Teachers' Committee. The back-paper examination covers the entire syllabus of the course.

In case of back-paper examination in a module-based course, there would be one single question paper covering both the modules with equal distribution of marks over the two modules. The total score obtained in a back-paper examination of any module-based course would be the total of the marks obtained in the two modules.

When a student takes a back-paper examination in any of these two types of courses, his/her final score in that course is the higher of the back-paper score and the earlier composite score, subject to a maximum of 45%.

A student may take more than the allotted quota of back-paper examinations in a given academic year and decide at the end of the academic year which of the back-paper examination scores should be disregarded.

Compensatory Paper Examination

A student who gets less than 35% in at most one course even after the back-paper examination in any semester, but 60% or more in average in the other courses in that semester is allowed to appear for a compensatory paper examination. In case of a module-based course, there will be one single question paper, like the back-paper examination, covering both the modules with equal distribution of marks over the two modules. A student will be allowed to appear in at most one compensatory paper in the entire programme. Maximum marks obtainable in a compensatory paper will be 35%. In the second semester, a student will have to choose between the compensatory paper examination and the possibility of repeating the programme. He/she will not be allowed to take both.
A student will have to discontinue the programme if he/she scores less than 35% in the compensatory paper in any semester.

Supplementary Examination

If a student misses the mid-semester or semester examination of a course or the examination for a module of a module-based course due to medical or family emergency, the Teachers' Committee may allow him/her to take a supplementary examination in the course for the missed examination, based on an adequately documented representation from the student. The supplementary semester examination for a non-module-based course is held at the same time as the back-paper examination for the semester and the student taking the supplementary semester examination in a course is not allowed to take any further back paper examination in that course. For a module-based course, the supplementary examination is held at a convenient time. The maximum that a student can score in a supplementary examination is 60%. Unlike the back-paper examination, the score in the supplementary examination is used along with other scores to arrive at the composite score. There will be supplementary examination for mid-semester, semester, back-paper and compensatory examinations within a month of the examination missed by a student due to medical or family emergency. The student should submit a written application to the Dean of Studies or the Academic Affairs In-Charge for appearing in the supplementary examination, enclosing supporting documents. On receipt of such an application from a student with supporting documents, the Dean of Studies or the Academic Affairs

In-Charge,, in consultation with the relevant Teachers' Committee, will decide whether such examination will be allowed. The student can score at most 60% in the supplementary examinations of mid-semester and semester examinations. For the back-paper or the compensatory papers, the maximum the student can score in the supplementary examination is 45% or 35% respectively.

Project

The one-course project in second semester will be on data analytics and will be supervised by a faculty. There is a regular assessment of the project work during the semester and at the end of the semester. The evaluation at the end of the semester is based on the final project report and presentation. The schedule and type of regular assessments and the weights to be given to the regular assessments and end-semester evaluation are announced beforehand by the Dean of Studies, or the Students' Academic Affairs In-Charge or the Class Teacher.

7 Satisfactory Conduct

A student is also required to maintain satisfactory conduct as a necessary condition for taking semester examination, for promotion and award of diploma. Failing to follow the examination guidelines, copying in examination, rowdyism, other breach of discipline of the Institute, unlawful/unethical behaviour and the like are regarded as unsatisfactory conduct. Violation of such nature is likely to attract punishments such as withholding promotion/award of diploma, withdrawing stipend and/or expulsion from the hostel/Institute.

Ragging is banned in the Institute. If any incident of ragging comes to the notice of the authorities, the concerned student shall be given liberty to explain, and if his/her explanation is not found to be satisfactory, he/she may be expelled from the Institute. The punishment may also take the shape of

1. suspension from the Institute for a limited period,
2. suspension from the classes for a limited period,
3. withholding stipend/fellowship or other benefits,
4. withholding results,
5. suspension or expulsion from hostel and the likes.

Local laws governing ragging are also applicable to the students of the Institute.

Guidelines during Examinations

The students are required to abide by the following guidelines during the examinations.

i) Students are required to take their seats according to the seating arrangement displayed. If any student takes a seat not allotted to him/her, he/she may be asked by the invigilator to hand over the answer script (i.e., discontinue the examination) and leave the examination hall.

ii) Students are not allowed to carry inside the examination hall any mobile phone with them – even in a switched-off mode. Calculators, books and notes will be allowed inside the examination hall only if these are so allowed by the teacher(s) concerned (i.e., the teacher(s) of the course), or if the question paper is an open-note/open-book one. Even in such cases, these articles cannot be shared.

iii) No student is allowed to leave the examination hall without permission from the invigilator(s). Further, students cannot leave the examination hall during the first 30 minutes of any examination. Under no circumstances, two or more students writing the same paper can go outside together.

iv) Students should ensure that the main answer booklet and any extra loose sheet bear the signature of the invigilator with date. Any discrepancy should be brought to the notice of the invigilator immediately. Presence of any unsigned or undated sheet in the answer script will render it (i.e., the unsigned or undated sheet) to be cancelled, and this may lead to charges of violation of the examination rules.

v) Any student caught cheating or violating examination rules will get 'Zero' in that examination. If the offence is in a back-paper examination, the student will get 'Zero' in the back-paper. (The other conditions for promotion, as mentioned in Section 8 below, will continue to hold).

The decisions regarding promotion in Section 8 and final result in Section 9 below are arrived at after taking in to account the violation, if any, of the satisfactory conduct by the student, as described in this section.

8 Promotion

A student is considered for promotion to the second semester of the programme only when his/her conduct has been satisfactory. Subject to the above condition, a student is promoted from first semester to second semester if

i) the number of composite scores less than 45% is at most two and
ii) no composite score in a course is less than 35%.

Otherwise, a student is not promoted to the second semester and he/she is asked to discontinue the programme.

9 Final Result

At the end of the second semester, the overall average of the percentage composite scores in all the courses taken in the two-semester programme is computed for each student. The student is awarded the post-graduate diploma in one of the following categories according to the criteria he/she satisfies provided in the second semester,

i) he/she does not have a composite score of less than 35% in any course,
ii) the number of scores less than 45% is at most one and
iii) his/her conduct is satisfactory.

Post-Graduate Diploma in Statistical Methods with Applications: passed in First Division with Distinction if

i) the overall average score is at least 75%, and
ii) the composite score in at most one course is less than 45%.

Post-Graduate Diploma in Statistical Methods with Applications: passed with First Division if

i) the overall average score is at least 60%,
ii) the composite score in at most one course is less than 45%, and
iii) not obtained First Division with Distinction.

Post-Graduate Diploma in Statistical Methods with Applications: passed with Second Division if

i) the overall average score is at least 45%,
ii) the composite score in at most two courses is less than 45%, and
iii) not obtained First Division with Distinction or First Division.

All others students are considered to have failed. A student who fails but obtains at least 35% average score in the second semester, and have satisfactory conduct is allowed to repeat the programme without any stipend all throughout the year provided that he/she has not taken the option of a compensatory paper examination in the second semester. A student is not given more than one chance to repeat.

10 Award of Certificate

A student passing the Diploma is given a certificate which includes

i) the list of all courses taken along with the respective composite scores, and
ii) the category (Passed with Distinction or Passed) of his/her final result.

The certificate is awarded in the Annual Convocation of the Institute following the semester II examinations.

11 Prizes and Medals

Students may be awarded prizes in form of book awards for good academic performances in each semester, as decided by the Teachers' Committee.

12 Class Teacher

One of the instructors of a class is designated as the Class Teacher. Students are required to meet their Class Teacher periodically to get their academic performance reviewed and to discuss their problems regarding courses.

13 Attendance

Every student is expected to attend all the classes. If he/she is absent, he/she must apply for leave to the Dean of Studies or the Academic Coordinator. Failing to do so may result in disciplinary action.

14 Stipend

Stipend, if awarded at the time of admission, is valid initially for the first semester only. The amount of stipend to be awarded in the second semester will depend on academic performance and conduct, as specified below, provided the requirements for continuation of the academic programme (excluding repetition) are satisfied.

Performance in course work: The composite scores considered for the following performance criteria are the composite scores after the respective back-paper examinations

i) If all the requirements for continuation of the programme are satisfied, and the average composite score is at least 60% and the number of courses with scores less than 45% is at most two in the first semester, then the full value of the stipend is awarded in the second semester.

ii) If all the requirements for continuation of the programme are satisfied, and the average composite score is at least 45% and the number of courses with scores less than 45% is at most one in the first semester, then the half value of the stipend is awarded in the second semester.

iii) In all other cases no stipend is awarded in the second semester.

Attendance: If the overall attendance in all courses in the first semester is less than 75%, no stipend is awarded in the following semester.

Conduct: At any time, the Dean of Studies or the Academic Affairs In-Charge or the Class Teacher, in consultation with the respective Teachers' Committee, may withdraw the stipend of a student fully for a specific period if his/her conduct in the campus is found to be unsatisfactory.

The net amount of the stipend to be awarded is determined by simultaneous and concurrent application of all clauses described above but in no case the amount of stipend to be awarded or to be withdrawn should exceed 100% of the prescribed amount of stipend. Stipends are given after the end of each month for eleven months in the academic year. The first stipend is given two months after the admission with retrospective effect provided the student continues in the Diploma programme for at least two months. Contingency grants can be used for purchasing a scientific calculator and other required accessories for the practical class, text books and supplementary text books

and for getting Photostat copies of required academic material. All such expenditure should be approved by the Class Teacher. No contingency grants are given in the first two months after admission.

15 Library Rules

A student is allowed to use the reading room facilities in the library and allowed access to the stacks. Student will have to pay a security deposit in order to avail himself/herself of the borrowing facility. The amount of security deposit will be specified at the time of the admission to the course. A student can borrow at most four books at a time. Fine is charged if any book is not returned by the due date stamped on the issue-slip. The library rules and other details are available in the library of the Centre to which the student is admitted.

16 Hostel Facilities

In case the Hostel Accommodation is provided to the students, the students will have to pay the caution money and the monthly room rent.

17 Change of Rules

The Institute reserves the right to make changes in the above rules, course structure and the curriculum as and when needed.

II. CURRICULUM

Semester I

1. Probability Theory
2. Statistical Methods I
3. Statistical Inference
4. Vectors & Matrices and Regression Methods
5. Programming: R and Python

Semester II

6. Statistical Methods II
7. Statistical Machine Learning
8. Statistical Modeling
9. Time Series and Statistical Finance
10. Project

18 Courses for Semester I

1. **Probability Theory**

Elementary concepts of probability: experiments, outcomes, sample space, events, axiomatic definition of probability and its properties. (8)

Conditional probability, independence, Bayes theorem. (5)

Random variable, probability distribution and properties; probability mass/density function, cumulative distribution function, expectation, variance, mean square error, moments. (7)

Bernoulli and Binomial, Poisson, Geometric and Negative Binomial, Hypergeometric, Uniform, Normal Exponential, Gamma, Beta distributions. (8)

Chebyshev's inequality, weak law of large numbers (statement and concept), central limit theorem (statement and concept). (2)

Distribution of a function of a random variable. (4)

Bivariate distribution for discrete and continuous random variables; joint, marginal and conditional distributions, moments, covariance, correlation coefficient. Bivariate Normal Distribution (8)

Independent random variables and their sums. Transformation of two random variables. (6)

Sampling distributions under the assumption of normality: chi-square, t, F. (4)

Suggested References:

a) Introduction to Probability and Statistics for Engineers and Scientists - Ross, S.
b) Elementary Probability Theory - Chung, K. L.
c) Introduction to Probability Theory - Hoel P. G., Port S. C. and Stone, C. J.
d) Introduction to Probability - Roussas, G.
e) Applied Statistics and Probability for Engineers - Montgomery, D.C. and Runger, G.C.
f) A First Course in Probability - Ross, S.

2. **Statistical Methods I**

Introduction to data, statistical problems and related data analysis. Concept of population, sample and statistical inference through examples. (4)

Summarization of univariate data; graphical methods, measures of location, spread, skewness and kurtosis; outliers and robust measures, sample moments. Empirical cumulative distribution function. (12)

Statistical computations: data summary and graphical display of data, basic statistics. Plotting empirical cumulative distribution function. (4)

Data simulations from discrete and continuous probability distributions: Bernoulli and Binomial, Poisson, Geometric and Negative Binomial, Hypergeometric, Uniform, Normal, Exponential, Chi-Square, Gamma, Beta. (8)

Analysis of discrete and continuous data: fitting some standard discrete and continuous probability distributions. Goodness of fit: Pearson's Chi-square test, Kolmogorov-Smirnov test. Graphical methods of verifying the fit: Q-Q and P-P Plots. Shapiro-Wilks test for Normality. (8)

Introduction to resampling (bootstrap) and cross-validation techniques. (4)

Introducing the analysis of variance; one way analysis, F test, Kruskal-Wallis nonparametric test; two way analysis. Designs of experiment: principles of designing an experiment. Introduction to CRD, RBD, Balanced and Unbalanced Block Designs, cross over designs with applications in industrial and clinical trials. (12)

(All computations and data analysis are expected to be done using R/Python.)

Suggested References:

a) Introductory Statistics - Ross, S
b) Statistics - Freedman, D., Pisani R. and Purves, R.
c) Applied Statistics and Probability for Engineers - Montgomery, D.C. and Runger, G.C.
d) Introduction to Probability and Statistics for Engineers and Scientists - Ross, S.
e) Design and Analysis of Experiments - Montgomery, D.C.
f) An Introduction to Statistics with Python- Haslwanter T.
g) A Handbook of Statistical Analysis using R - Everitt, B. S. and Hothorn, T.

3. **Statistical Inference**

Brief introduction to random variable and probability distributions. Random sample and the concept of statistical Inference with examples.(6)

Point estimation: estimator and estimate. Desirable properties of an estimator: unbiasedness, smaller variance and mean squared error. Method of moments and maximum likelihood estimation. Asymptotic behaviour of MLE (statement on consistency and asymptotic normality). (8)

Interval estimation- Confidence interval and its basic properties, Construction of confidence interval for parameter of Uniform distribution, exponential distribution, mean of the normal distribution with known and unknown variance. (6)

Hypotheses and the concept of hypotheses testing. Null and alternative, simple and composite hypothesis, significance level, size, p-value and power. Introduction to likelihood ratio tests with examples. (12)

One sample problem: Test for randomness - run test. Test for mean under the assumption of normality with known and unknown variance. Nonparametric tests for median: signed test, Wilcoxon's signed rank test. One sample test for proportion. (10)

Comparison of two samples- Two independent samples: graphical procedures, K-S test. Comparing mean under the assumption of normality (two sample t test). Nonparametric test for medians - Mann-Whitney-Wilcoxon. Two sample test for proportion. Two dependent samples: paired t test under the assumption of normality, Nonparametric tests for two dependent samples. (10)

Suggested References:

a) Introductory Statistics - Ross, S
b) Introduction to Statistical Theory - Hoel P. G., Port S. C. and Stone, C. J.
c) An Introduction to Probability and Statistical Inference - Roussas, G.
d) Applied Statistics and Probability for Engineers - Montgomery, D.C. and Runger, G.C.
e) Introduction to Probability and Statistics for Engineers and Scientists - Ross, S.

4. **Vectors & Matrices and Regression Methods**

Vectors & Matrices (24)

Introduction to Vectors and matrices.

Vectors: Definition and examples, vector spaces and subspaces, basis of a vector space, linear dependence/independence (4).

Matrices: Definition and examples, matrix as a linear transformation, elementary matrices and elementary matrix operations, basic matrix operations including those of partitioned matrices, rank, nullity, trace, determinant and inverse of a matrix, idempotent matrix and its properties. Solutions of system of equations (14)

Spectral theory: eigenvalues and eigenvectors of matrices, decomposition of matrices, quadratic forms and definiteness of a matrix (with applications in Statistics) (6)

Suggested References:

a) Matrix Algebra: Theory, Computations and Applications in Statistics - Gentle, J. E.
b) Matrix Algebra useful for Statistics - Searle, S.
c) Matrices with Applications in Statistics - Graybill, F. A.
d) Matrix Algebra From a Statistician's Perspective - Harville, D. A.

Regression Methods (28)

Introduction to Classical Linear Regression Model (2).

OLS method of estimation; fitted values, prediction of the response variable, tests of hypotheses. (6)

Residuals. Validation of assumptions using graphical techniques. Regression Diagnostics (10)

Use of dummy variables in regression (2);

Variable selection, multicollinearity. Model selection using AIC and BIC criteria. (4)

Concepts of robust and nonparametric regression (4).

Illustration of the methodology with real data.

Suggested References:

a) Introduction to Linear Regression Analysis - Montgomery, D. C., Peck, E. and Vinning, G.
b) Regression Analysis by Examples - Chatterjee S. and Hadi, G.
c) Applied Linear Regression - Weisberg, S.
d) Applied Regression Analysis - Draper, N.R. and Smith, H.

5. **Programming: R and Python**

Introduction to packages- R and Python: overview of packages, data handling, input-output operations. Basic programming: data types, arrays, loops etc.; functions and graphics.(12 + 12)

Improvement of the initial solution using methods of bisection, sort and search, Regula Falsi and Newton-Raphson. (6)

Fixed point iterative schemes, significant digits, round-off errors, finite computational processes and computational errors. Order of convergence and degree of precision.(4)

Matrix computations - basic operations, finding determinant, inverse, eigen roots and eigen vectors of a matrix, matrix decomposition, solving system of equations. (6)

Computational aspects of constrained optimization (4).

Unconstrained optimization: Newton, Quasi-Newton method. (4)

Experimentation designs: Obtaining global optimal solutions from local optimum solutions using iterative experimentation like Response Surface Methodology. (4)

Suggested References:

a) Beginning R: The Statistical Programming Language - Gardener, M.

b) Computational Statistics: An Introduction to R - Sawitzki, G
c) Optimization - Lange, K.
d) Dive into Python - Pilgrim, M.
e) An Introduction to Statistics with Python- Haslwanter T.
f) A Handbook of Statistical Analysis using R - Everitt, B. S. and Hothorn, T.

19 Courses for Semester II

6. **Statistical Methods II**

Multivariate Data Exploration/visualization, multivariate data handling, random vector, mean and variance-covariance matrix, introduction to multinomial and multivariate normal distributions. (10)

Applied Multivariate techniques: Principal components analysis and Factor Analysis. (10)

Introduction to discrete time Markov chains, finite and countable state space. Introduction to Markov chain Monte Carlo (MCMC) methods and applications of MCMC method in statistics. Introduction to HMM algorithm. (10)

Handling missing data; various methods of imputations including hot deck algorithm (MICE in R), EM algorithm (6)

Advanced regression techniques: Ridge, Principal component regression, LASSO and Spline smoothing (8)

Multiple Hypotheses testing. (4)

Introduction to MANOVA and Hotelling's t^2. (4)

Illustration of the methodology with real data.

Suggested References:

a) Applied Multivariate Statistical Analysis - Johnson, R.A. and Wichern, D.W
b) A User's Guide to Business Analytics - Basu, A. and Basu, S.
c) Computational Statistics - Gentle, J. E.
d) Handbook of Computational Statistics - Gentle, J.E., Hardle, W. and Mori, Y.

e) Statistical Computing: Existing Methods and Recent Developments - Basu, A. and Kundu, D.
f) Applied Nonparametric Regression - Hardle, W.
g) Introducing Monte Carlo Methods with R - Robert, C. P. and Casella, G.

7. **Statistical Machine Learning**

Introduction to bootstrap based machine learning. Assessment and model selection: confusion matrix and various criteria of evaluation, training and testing error rates. (8)

Pattern Recognition and Classification techniques

Unsupervised learning: clustering procedures: hierarchical and non-hierarchical, k-means; association rules, ROCs. (8)

Supervised learning: Linear and quadratic discriminant analysis; Bayesian classifier, nearest neighbour classifier, Entropy based classifier. (10)

Tree based classification methods: predictive modeling using decision trees (CART), random forests. (8)

Support vector machine. Introduction to boosting and adaptive boosting algorithm. (6)

Introduction to Natural Language Processing (NLP), information retrieval and text analysis: stop words, TF-IDF measure, vector space models. (6)

Introduction to neural networks, Convolutional NN, Deep NN. (6)

Illustration of the methodology with real data.

Suggested References:

a) The Elements of Statistical Learning With Applications in R - James, G., Witten, D., Hastie, T. and Tibshirani, R.
b) Introduction to Statistical Learning Theory - Hastie, T., Tibshirani, R. and Friedman, J.
c) A User's Guide to Business Analytics - Basu, A. and Basu, S.
d) Data Mining: Concepts and Techniques - Han, J. and Kamber, M.
e) Classification and Regression Trees - Breiman, L. et al
f) Statistical and Machine-Learning Data Mining - Ratner, B.

8. **Statistical Modeling**

Logistic regression; odds ratio, concordance-discordance measures, Logistic Regression as a classsifier. Probit Regression. Introduction to Multilogit models. (10)

Modeling count data: Poisson Regression, Poisson models for zero inflated data. (8)

Introduction and visualizing categorical data. Measures of association. Loglinear Models, Models for nominal and ordinal response. (8)

Survival Data Modeling: Time-to-event data and survival probabilities, notion of censoring, survival curve and other ways of representing survival distribution, Kaplan-Meier and Nelson-Aalen estimates, log-rank test, Cox's proportional hazard model. Parametric survival models for Exponential, Gamma, Wiebull distributions. (12)

Bayesian Inference and Modeling: Prior and posterior distributions, Bayesian models, Bayesian regression, Hierarchical Bayes models (10).

Introduction to mixture models (4)

Illustration of the methodology with real data.

Suggested References:

a) Applied Logistic Regression - Hosmer, D.W. and Lemeshow, S.
b) An Introduction to Categorical Data Analysis - Agresti, A.
c) Analysis of Categorical Data with R - Bilder, C. R. and Loughlin, T. M.
d) Visualizing Categorical Data - Friendly, M.
e) Survival Analysis: A Self-Learning Text - Kleinbaum, D. G. and Klein, M.
f) Applied Survival Analysis: Regression Modeling of time-to-event data. - Hosmer, D.W., Lemeshow, S. and May, S.
g) Log Linear Models and Logistic Regression - Christensen, R.
h) Bayesian Statistical Modelling - Congdon, P.
i) Bayesian Data Analysis - Gelman, A., Carlin, J. et al.
j) Bayesian Essentials with R - Marin, J. and Robert, C.
k) Applied Bayesian Hierarchical Methods - Congdon, P.

9. **Time Series and Statistical Finance**

Time Series (28)

Exploratory analysis and graphical display; trend, seasonal and cyclical components. Decomposition of time series into components, Smoothing. (5)

Stationary Time Series: Brief Introduction to AR, MA and ARMA models; Box-Jenkins correlogram analysis, ACF and PACF, introduction to periodogram, choice of AR and MA orders. (11)

Non-Stationary Time Series: introduction to ARIMA model; deterministic and stochastic trends; introduction to ARCH and GARCH models. (8)

Forecasting: basic tools, using exponential smoothing and Box-Jenkins method. Residual analysis.(4)

Illustration of the methodology with real data.

Suggested References:

a) Introduction to Time Series and Forecasting - Brockwell, P. and Davis R. A.
b) Analysis of Time Series - Chatfield, C.
c) Time Series Analysis and Its Applications with R - Shumway, R.H. and Stoffer, D.S.
d) Introduction to Time Series Analysis and Forecasting - Montgomery, D.C., Jennings, C.L., Kulachi, M.
e) Forecasting: Methods and Applications - Makridakis, S.G., Wheelwright, S.C. and Hyndman, R.J.

Statistical Finance (28)

Introduction to stock prices, returns and log-returns. Distribution of returns, Assessing Normality using skewness, kurtosis and q-q plots. (4)

Market return and risk free rate. Capital Asset Pricing Model (CAPM). Estimating beta and testing for CAPM. (6)

Options. Arbitrage and risk-neutral measure. European and American options. Option pricing using Binomial model: 1 and 2 step. Black-Scholes model (statement only), interpretation of drift and volatility. (8)

Value at risk and expected shortfall. Quantile estimation. Estimation of tail-index. (6)

Markowitz Portfolio Theory. Resampling for assessing estimation of Efficient Portfolio. (4)

Illustration of methodology with real data.

Suggested References:

a) Statistics and Finance - Ruppert, David
b) Statistical Analysis of Financial Data in R - Carmona, Rene
c) Options, Futures and other Derivatives - Hull, John C. and Basu, S.
d) Risk-Neutral Valuation - Bingham, N. and Keisel, R.

10. **Project**
