Aliah University

Department of Statistics & Informatics

Detailed Syllabus
for
2-year M. Sc. in Statistics
with effect from 2016-17

Aliah University, IIA/27, Newtown, Kolkata-156

Contents

2-year M. Sc. in Statistics

1.1 Semester-I

1.1.1 STAT-101 Mathematical Analysis and Linear Algebra

Course objectives

In this course students will learn

- Real numbers and their convergence, limit, Continuity and uniform Continuity, Differentiability and related problems
- Riemann integral, Improper integrals, Line integral, Multiple integrals.
- Several aspects of linear algebra which are necessary to develop various statical theories
- Real quadratic forms, reduction of pair of real symmetric matrices, Singular value decomposition.
- Vector and matrix differentiation, Optimum values of a quadratic forms.

Learning Outcomes

At the end of the course a student will be able to

- Check convergence of sequence and series of real numbers
- Solve problems related to limit, continuity, differentiability of univariate and multivariate real valued functions
- Find rank of various matrices and solve system of linear equations.
- Find generalized inverses
- Find optimum values of linear form, quadratic forms, bilinear form and their examples in Statistics

Detailed syllabus

Review of Real and complex numbers; Open, closed and compact sets in R^n; Sequences and Series, Convergence, Real valued functions, Limit, Continuity and uniform Continuity, Differentiability of Univariate and Multivariate functions, Sequences and series of functions, improper integrals, Mean value theorems etc.

Uniform convergence, Power series, Taylor series. Riemann integral, Line integral, Multiple integrals.

Review of finite dimensional vector spaces (Null space and nullity), Linear dependence and independence, Matrix algebra, Rank of a Matrix, Inverse of a non-singular matrix. Hermite canonical forms, Generalized inverses, solution of linear equations, Projection and orthogonal projection matrices, Idempotent matrices. Real quadratic forms, reduction of pair of real symmetric matrices, Singular value decomposition. Optimum values of a quadratic forms, Vector and matrix differentiation.

1.1.2 STAT-103 Probability Theory

In this course students will learn

- probability as a measure.
- probability inequalities
- convergence of random variables

Learning Outcomes

At the end of the course a student will be able to

- Check field, sigma field, and related problems.
- Check whether a measurable or not and study its properties.
- Solve problems involving probability inequalities
- Check convergence of random variables.
- Find asymptotic distributions.

Detailed syllabus

Review of probability concepts, fields, sigma-fields and generators, semi-fields, Borel sigma-field on R. Monotone classes, monotone class theorem, pi-lambda theorem.

Measures, finite, sigma-finite measures. Measurable functions and properties. Generated sigma-fields. Induced measures. Compositions. Examples. Probability measures, properties. Independence of events, Borel-Cantelli lemmas. Fubini's theorem. Independence of random variables. Sums, variances, covariances. Kolmogorov's 0-1 law. Weak and strong laws of large numbers. Kolmogorov's inequality.

Convergence in distribution. Scheffe's theorem, Slutsky's theorem. Law of Types. Asymptotic normality. Integration of complex-valued functions, characteristic functions. Inversion and Continuity theorems. Central Limit Theorems.

1.1.3 STAT-105 Regression Analysis

Course Objectives

This is one of the most important courses in the post-graduation curriculum. The course is designed to make students aware of the linear models, usual linear model assumptions, deviations from the usual linear model assumptions and regression diagnostics. Among several other components, this course aims to give students practical exposures through assignments and problem sets.

Learning Outcomes

The course makes students industry ready. It exposes them towards the deviations from Gauss Marcov set up. It will teach them the techniques for model parameter assumptions under the presence of heteoscadasticity, autocorrelation and multi-colinearity. It helps students to handle data and have a strong building block on statistical modeling. Also upon taking the course, students might consider taking the elective paper, STAT206B (Advanced Regression Analysis), which gives them huge exposure on discrete data analysis.

Detailed syllabus

General theory of regression, fitting of polynomial regression by orthogonal methods, multiple regression, examination of regression equation. Analysis of variance for fixed, random and mixed models.

Gauss-Markov set-up, estimation function BLUE and Gauss-Markov Theorem estimation and error spaces, estimation with correlated observations. Least squares estimations with restriction on parameters.

Model selection problems. Concept of best subset regression, stepwise regression, Ridge regression, Logistic regression etc.

Departures from the Gauss-Markov set-up: Heteroscedasticity, Autocorrelation and Multicolinearity. Checking for normality: Q-Q plots, Normal Probability plot, Shapiro-Wilks test. Residuals and their plots. Detection of outliers.

1.1.4 STAT-107 Statistical Methodology

Course Objectives

Upon completion of this course, students will be able to:

- Know the most common distributions and the exponential family.
- Be familiar with transformation of univariate and multivariate densities.
- Know the concept of covariance and conditional probability.
- Have complete idea of truncated distribution, compound distribution and mixture of distribution.
- Know the different notions of convergence in statistics like convergence in probability, almost sure convergence and convergence in distribution.
- Be familiar with the concept of sufficiency and the likelihood principle.
- Understand Order Statistics.
- Have some knowledge of asymptotic statistics.

Learning Outcomes

Upon completion of this course, students will be able to:

- Explain the concept of estimation of parameters.
- Calculate the problems related to point estimation and interval estimation.
- Explain the concepts of Testing of Hypotheses, (Large Sample Tests small sample test).
- Know the most important estimation methods like maximum likelihood, least square and the method of moments.
- Handle a parametric hypothesis testing problem and to use the likelihood ratio method.
- Hypothesize various advanced statistical techniques for modelling and exploring practical situations.
- Interpret, in plain language, the application and outcomes of statistical techniques.

Detailed Syllabus

Brief review of basic distribution theory. Symmetric Distributions, truncated and compound distributions, mixture of distributions, Power series distribution, exponential family of distributions, Characterization of distributions (Geometric, negative exponential, normal, gamma), non-central χ^2, t and F distributions and their properties.

Parametric models, parameters, random sample and its likelihood, statistic and its sampling distributions, problems of inference. Examples from standard discrete and continuous models such as Bernoulli, Binomial, Poisson, Negative Binomial, Normal, Exponential, Gamma, Weibull, Pareto etc. Concept of sufficiency, minimal sufficiency, Neyman factorization criterion, Fisher information, exponential families. Maximum likelihood estimators, method of moment estimators. Rao Blackwell theorem, Cramer-Rao lower bound, different examples.

Approximating distributions, Delta method and its applications. Approximating distributions of sample moments, limiting moment generating function, Poisson approximation to negative binomial distribution. Order statistics-their distributions and properties. Joint and marginal distributions of order statistics. Extreme values and their asymptotic distributions (statement only) with applications. Tolerance intervals, covariance of $(X_{(r)}, X_{(s)})$.

1.1.5 STAT-191 Programming Languages

Course Objectives

In this course students will learn and practice

- Various statistical computation techniques using C
- Writing and compiling programs in R, exporting and importing data sets, writing outputs in word.
- Loops and controls in R, functions in R
- Statistical computations in R

Learning Outcomes

At the end of the course a student will be able to

- Write program for statistical computations in C.
- Write and execute programs in R.
- Do statistical computations using R.

Detailed syllabus

Introduction to C language. Simple Syntax, loops, pointers, arrays, functions, files. Introduction to data structures in C Programming Language. Algorithms and corresponding C-programs for Sorting and Searching, Generation of Random Numbers, generation of samples from different theoretical distributions etc.

Introduction to R; R help; help.search(), R mailing list, contributed documentation on CRAN. Data types in R : numeric/character/logical; real/integer/complex, strings and the paste command, matrices, data frames, lists, Creation of new variables, Creation of patterned variables, Saving workspace/history.

Writing programs in R markdown.

Graphs in R: the plot command, histogram, bar plot, box plot, points, lines, segments, arrows, inserting mathematical symbols in a plot,pie diagram, Customization of plot setting graphical parameters, adding text, saving to a file; Adding a legend.

Functions & loops in R, Programming in R.

Basic statistics using R: one and two sample t tests, Bartletts test for variance,F test for equality of variances, multi sample means, Nonparametric tests, Chi squared tests, Exact tests and confidence intervals.

Vector matrix operations: Matrix operations such as addition, subtraction, multiplication,; Linear equations and eigenvalues, matrix decomposition - LU, QR and SVD; matrix inverse.

Linear models: the lm function; ANOVA/ANCOVA/regression, models, the summary function, goodness of fit measures, predicted values and residuals.

Random no. generation & Simulations: runif, rnorm, rchisq, rt, rbinom, sample etc.; set.seed, Monte Carlo techniques.

1.1.6 STAT-193 Statistical Lab-I

Course Objectives

In this course students will do hands on

- Finding inverse, determinant, g-inverse, and rank using R
- Fitting linear model using linear regression
- Fitting best polynomial model
- Model section techniques
- Outlier detection and multicoliearity problem
- Shrinkage Methods in regression
- Estimation of model parameters using method of moments and maximum likelihood method.

Learning Outcomes

At the end of the course a student will be able to

- Find the inverse, determinant, g-inverse, and rank using R
- Fit best linear model and do the interpretation of model
- Non-linear model using polynomial regression
- Fit regression model using Ridge regression and Lasso
- Estimate model parameters using method of moments and maximum likelihood method

1.1.7 AI-131 Elementary Arabic and Islamic Studies

This is a compulsory course.

1.2 Semester-II

1.2.1 STAT-102 Design of Experiments

Learning Objectives

Upon completion of this course, students will be able to:

- Discuss the fundamental principles of Design of Experiment.
- List the different types of formal experimental designs (e.g. completely randomised, randomised block, repeated measures, Latin square and factorial experimental designs).
- Understand total and partial confounding and its analysis.
- Explain Multiple comparison techniques due to Scheffe and Tukey.
- Explain various types of incomplete block design and its analysis.
- Frame mutual orthogonal latin square design and its analysis.

Learning Outcomes

Upon completion of this course, students will be able to:

1. Design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions.
2. Make use of the basics of the Design of Experiments such as randomization and blocking
3. Describe some of the factors affecting reproducibility and external validity.
4. Identify common and important types of experimental designs with respective advantages and disadvantages (power, cost/workload).
5. Explain the fundamental principles behind the output of an ANOVA, including "blocking" and "interactions".
6. Interpret the model and report the findings scientifically.

Detailed syllabus

Review of factorial designs, fractional, factorial design.

Ideas of CRD, RBD and LSD.

General linear hypothesis - related sampling distribution, Multiple comparison techniques due to Scheffe and Tukey. Block designs: - concepts of connectedness, orthogonality and balance; intra-block analysis - BIB: BIB design ,Youden Square design.

Construction of complete classes of mutual orthogonal Latin squares (MOLS): construction of BIBD through MOLS finite geometry and Bose's fundamental method of differences, other orthogonal designs.

1.2.2 STAT-104 Database Management Systems

1.2.3 Course Objective

1. The objective of the course is to present an introduction to database management systems, with an emphasis on how to organize, maintain and retrieve - efficiently, and effectively - information from a DBMS.
2. Learn the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL.
3. Design ER-models to represent simple database application scenarios and convert the ER-model to relational tables, populate relational database and formulate SQL queries on data.

1.2.4 Learning Outcomes

1. Know the basic data models.
2. Draw ER-Diagram and convert into a RDBMS.
3. Write SQL queries from basic queries in DBMS by using standard relational operators.

1.2.5 Detailed Syllabus

Introduction to Databases and Transactions. Data Models: The importance of data models, Basic building blocks, Business rules, The evolution of data models, Degrees of data abstraction. Database Design, ER-Diagram and Unified Modeling Language: Database design and ER Model: overview, ER-Model, Constraints, ER-Diagrams, ERD Issues, weak entity sets, Codd's rules, Relational Schemas.

Relational algebra: introduction, Selection and projection, set operations, renaming, Joins, Division, syntax, semantics, computational capabilities

Constraints and SQL What is constraints, types of constrains, Integrity constraints, Views: Introduction to views, data independence, security, updates on views, comparison between tables and views SQL: data definition, aggregate function, Null Values, nested sub queries, Joined relations.

1.2.6 STAT-106 Statistical Inference-I

Course objectives

In this course students will learn

- Statistical hypothesis testing and construction of test statistics under different distributional assumptions with examples.
- construction of Likelihood ratio test with examples.
- Optimum parametric confidence intervals for large samples

Learning Outcomes

At the end of the course a student will be able to

- perform statical hypothesis testing and interpretation of results.
- do likelihood ratio test.
- Test for significance of correlation coefficient.
- perform Large sample tests

Detailed syllabus

Statistical Hypotheses-simple and composite, statistical tests, critical regions, Type-I and Type-II errors, size and power of a test, Neyman Pearson lemma and its different applications. Most powerful test, uniformly most powerful test, unbiased test and uniformly most unbiased test. Likelihood ratio test.

Likelihood Ratio tests and its applications to tests for the equality of means and variances of several normal populations. Generalized Neyman -Pearson Lemma. UMPU test or one parameter families, Locally best tests, Similar tests, Neyman structure. UMPU tests for composite hypotheses.

Confidence sets: relation with hypothesis testing. Optimum parametric confidence intervals Large Sample Theory

Delta method, Derivation of large sample standard error of sample moments, standard deviation, coefficient of variation, b_1 and b_2 measures, and correlation coefficient and their uses in large sample tests under, normality assumption, large sample distribution of sample quartile.

Transformation of statistics to stabilize variance: derivation and use of $\sin^{-1}$, square root, logarithmic and z transformations. Large sample tests for binomial proportions, Poisson means (single and two independent samples cases).

Large sample distribution of Pearsonian χ^2-statistic and its uses. Yate's correction in a 2×2 contingency table.

1.2.7 STAT-108 Statistical Simulation

Course Objective

The purpose of this course is to provide students with an opportunity to develop skills in modeling and simulating data from different probability distribution. After learning the simulation techniques, the students are expected to be able to solve real world problems which cannot be solved strictly by mathematical approaches.

Learning Outcomes

Students will have ability to generate sample from different probability distributions. They can also acquire knowledge on computer intensive inference methods like Jack-Knife, Bootstrap, cross validation, Monte Carlo methods.

Detailed syllabus

Simulation of random variables from discrete, continuous, multivariate distributions and stochastic processes, Monte-Carlo methods. Regression analysis, scatter plot, residual analysis. Computer Intensive Inference Methods - Jack-Knife, Bootstrap, cross validation, Monte Carlo methods and permutation tests, Importance sampling, Metropolis Hastings Algorithm.

1.2.8 STAT-1010 Stochastic Processes

Course objectives

In this course students will learn

- Stochastic process and deterministic processes and their distinction and examples
- Markov chains with finite and countable state space, classification of states, Chapman - Kolmogorov equation
- Calculation of n-step transition probability and its limit, stationery distribution for discrete time Markov processes

- Continuous time discrete state space stochastic process including Birth and death process, Branching process
- Distribution of population size for Continuous time Markov chain with examples

Learning Outcomes

At the end of the course a student will be able to

- Classify a stochastic process with respect to state space and time
- Derive the m-step transition probability distribution
- Will be able to estimate the transition probability matrix when the realization of the process is available.
- Classify a state and its behavior
- Explain when stationary distribution exists and able to derive the stationary distribution if exists
- Model discrete state space stochastic process and study their behavior

Detailed syllabus

Introduction to stochastic process. Markov chains with finite and countable state space, classification of states, Chapman - Kolmogorov equations. Calculation of n-step transition probability and its limit. Stationery distribution. Random walk. Discrete state space continuous time Markov chains. Poisson process, gambler's ruin problem.

Birth and death process, Renewal theory: Statement and uses of key renewal theorem. Branching process. Galton-Watson branching process, estimation of probability of extinction. Brownian motion.

1.2.9 STAT-192 Statistical Lab-II

1.3 Semester-III

1.3.1 STAT-201 Multivariate Analysis-I

Course Objectives

Objective of this course is to focus on the statistical inference of the multivariate model. Different techniques of point estimation, testing of hypothesis and multivariate analysis of variance will be discussed through lecture.

Learning Outcomes

Acquire knowledge on Hotelling T2 and Mahalanobis's D2 and its application on multivariate testing of hypothesis. Students will be able to transfer any practical problem to a multivariate model and will be able to provide inference of the model parameters.

Detailed syllabus

Multivariate normal distribution and its properties. Sampling from Multivariate normal distribution - independence of sample mean vector and variance-covariance matrix. Wishart distribution.

Hotelling T^2 and Mahalanobis's D^2 application in testing and confidence set construction. Multivariate linear model: estimation of parameters, tests of linear hypotheses, Multivariate Analysis of variance of one and two way classified data (only LR test).

1.3.2 STAT-203 Sample Survey

Course Objective

1. The aim of this course is to cover sampling design and analysis methods that would be useful for real life decision making problem. A well designed sampling procedure ensures that we can summarize and analyze data with a minimum of assumptions and complications.

2. Learn the basics of sampling from finite populations and analyze various sampling design such as simple random sampling, stratified sampling, unequal probability sampling, and other sampling design.

Learning Outcome

1. Construct different estimators for population parameters by knowing the sampling design.

2. Learn the the differences of equal and unequal probability sampling methods.

3. Explicit uses of auxiliary variables in different sampling techniques.

4. Derive optimum sample size in a given sampling design with predefined constraints and different estimator from a given sample.

Detailed syllabus

Probability sampling from a finite population - Notions of sampling design, sampling scheme, inclusion probabilities, Horvitz-Thompson estimator of a population total. Basic sampling schemes - Simple random sampling with and without replacement, Unequal probability sampling with and without replacement, Systematic sampling. Related estimators of population total/mean, their variances and variance estimators, Hansen-Hurwitz estimator in unequal probability sampling with replacement, Stratified sampling - Allocation problem and construction of strata.

Ratio, product, difference and regression estimators, unbiased ratio estimators, probability proportional to aggregate size sampling.

Sampling and sub-sampling of clusters. Two-stage sampling with equal/unequal number of second stage units and simple random sampling without replacement / unequal probability sampling with replacement at first stage, Ratio estimation in two-stage sampling.

Double sampling for stratification.Double sampling ratio and regression estimators. Sampling on successive occasions.

1.3.3 STAT-205 Statistical Inference-II

Course objectives

In this course students will learn

- Statistical hypothesis testing under non-parametric setup.
- Bayesian inference and its comparison with parametric and non-parametric inference
- How to find Bays estimator under different loss function.

Learning Outcomes

At the end of the course a student will be able to

- Perform various non-parametric tests.
- Find Bayes estimator.

Detailed syllabus

Nonparametric Methods: Sign test, Mann-Whitney test, Run test, Test of randomness, Confidence limits for Quantiles based on Sign test statistic.

Bayesian Analysis: Overview and comparison of the three paradigms, classical statistics, data analysis and Bayesian analysis. Relative advantages and disadvantages.

Choice of subjective priors conjugate priors. Loss functions - squared error, absolute error and 0 - 1; reach function.Bayesian estimation of parameters.

1.3.4 STAT-207 Linear Programming

Formation of Linear programming problems. Convexity, Extreme points, Supporting hyper planes etc., Simplex Algorithm- Algebraic and Geometrical approaches, Artificial variable technique, Duality Theory: Fundamental theorem, Dual simplex method, Primal-dual method, Sensitivity Analysis, Bounded Variable L.P.P. Transportation Problems: Models and Algorithms, examples.

1.3.5 STAT-209 Elective Paper-I

Any one from the following:

1. **STAT-209A Reliability Theory**

Course Objectives

This course is a part of statistical methods for industrial engineering. This course aims students to make students aware of the tools and techniques that are used to cater customer satisfaction. Together with the course on statistical quality control (SQC) from under-graduation, this course has been built to make students fully aware of how manufacturing industry operates.

Learning Outcomes

Upon completion of the course, students become suitable for jobs in manufacturing industry. This course helps them to understand several manufacturing systems like coherent system, series and parallel system and many more. It will expose them to bivariate life distributions and several censoring techniques. The inferential methods for the reliability theory will also be discussed. Those who take this course, will acquire the capability of collaborating with people from industrial engineering background. This course gives the students the knowledge of systems engineering too and thereby the opportunity to work as a statistical consultant of several software companies open up.

Detailed syllabus

Reliability: concepts and measures, components and systems, coherent systems, reliability of coherent systems.

Life-distributions, reliability function, hazard rate, Mean residual life, common univariate life distributions - exponential, weibull, gamma, etc..Bivariate exponential.

Notions of ageing - IFR, IFRA, NBU, DMRL and NBUE classes and their duals, preservation of such classes under reliability operations, Loss of memory property,Partial ordering of life distributions.

Reliability estimation based on failure times from variously censored life-tests data for parametric families.

Kaplan - Meier estimation of reliability curve, Greenwood formula, Non-parametric methods for comparison of several reliability curves, Log rank tests.

Regression models in reliability, Cox PH and Accelerated failure time models; Estimation of parameters and diagnostics.

2. **STAT-**209**B Statistical Techniques in data Mining**

   Introduction to Data Mining and its Virtuous Cycle.

   Cluster Analysis: Hierarchical and Non hierarchical techniques. Classification and Discriminant Analysis Tools: CART, Random forests, Fisher's discriminant functions and other related rules, Bayesian classification and learning rules.

   Dimension Reduction and Visualization Techniques: Multidimensional scaling, Principal Component Analysis, Chernoff faces, Sun-ray charts.

   Algorithms for data-mining using multiple nonlinear and nonparametric regression. Neural Networks: Multi-layer perception, predictive ANN model building using back propagation algorithm. Exploratory data analysis using Neural Networks - self organizing maps. Genetic Algorithms, Neuro-genetic model building.

3. **STAT-**209**C Demography**

   Definition of concepts: Life and Death, Death Rates - age, space and cause specific. Adjusted death rates, Fatality: Birth rates- age-sex adjusted, Quality Adjusted Life. Migration-related measures. Life tables- constructions and applications.

   Growth curve models, Population Estimation and Projection, Methods for Population projection. Stable and quasi stable population, intrinsic growth rate.

1.3.6 STAT-291 Statistical Lab-III

1.4 Semester-IV

1.4.1 STAT-202 Multivariate Analysis-II

Course Objectives

Applied multivariate data analysis techniques like cluster analysis, factor analysis, principal component analysis will be explored in this course. Multivariate classification and discrimination techniques will also be discussed.

Learning Outcomes

Students will be able to reduce the dimension of multivariate data and they can summarize the data principal component analysis technique. They also can classify or cluster the data coming from different populations.

Detailed syllabus

Clustering: Hierarchical clustering for continuous and categorical data - different choices of proximity measures, Agglomerative and Divisive algorithms, K-means clustering - optimum choice of the number of clusters.

Classification and discrimination procedures: Discrimination between two known populations - Bayes, Minimax and Likelihood Ratio procedures. Discrimination between two multivariate normal populations. Sample discriminant function. Likelihood ratio rule. Probabilities of misclassification and their estimation.

Principal Component Analysis: Population and sample Principal components and their uses. Plotting techniques.

Factor Analysis: The orthogonal factor model, Estimation of factor loading, Estimation of Factor scores, Interpretation of Factor Analysis.

1.4.2 STAT-204 Survival Analysis

Course Objectives

Course is a part of the courses in Bio Statistics, where the aim is to expose students to several tools and techniques that are used for complete/incomplete biological experimentations. This course describes the various methods used for modelling and evaluating survival data, also called time-to-event data. It aims to expose the students to handle real life data from clinical trials through several assignments and small projects.

Learning Outcomes

Upon taking this course, Students will gain the ability to recognize the difference between parametric and non-parametric (Kaplan Meier method) survival models, estimate survival probabilities both with and without the presence of covariates (Cox PH model). They will acquire the practical exposures to handle time to event data. This helps them to make themselves suitable for pharmaceutical industries, collaborations with the clinicians and pursuing higher studies in biostatistics.

Detailed syllabus

Introduction. Basic functions and Models. Censoring and Truncation.

Parametric univariate estimation : Standard models - exponential, Weibull, log-logistic, log-normal and Gamma.

Nonparametric univariate estimation : Actuarial, Kaplan-Meier and Nelson-Aalen estimators. Semi-parametric regression models: Cox proportional hazard model - estimation, tests, diagnostics. Some ideas of Additive Models, Accelerated Models and Frailty Models.

1.4.3 STAT-206 Elective Paper-II

Anyone from the following:

1. **STAT-206A Operations Research**

   Review of LPP, Inventory models: Objective, Nature, Definitions and Scope of O.R., O.R. Models.

   Inventory Control: General Inventory model; Deterministic models - Economic Lots size models (single item) with uniform rate of demand, different rates of demand, finite rate of replenishment, Quantity discounts, with shortages. Single period EOQ model, Probabilistic EOQ model. Single period with uniform demand, single period with discontinuous demand & time independent costs. ABC analysis.

   Queuing Theory : Queuing problems. $(M/M/1)$: $FIFO$, $(M/M/C)$.

   Replacement Models and their solutions. Sequencing.

2. **STAT-206B Advanced Regression Analysis**

Course Objective

(a) This course covers techniques and applications of generalized linear model for different data type.

(b) Learn association/relationship between different data type and will construct suitable GLM.

(c) Check for over-dispersion of the model through suitable techniques.

Learning Outcome

(a) Learn association between nominal-ordinal, nominal-nominal and ordinal-ordinal type table.

(b) Communicate the role of generalized linear modelling techniques (GLMs) in modern applied statistics and implement methodology.

(c) Explain the underlying assumptions for GLMs and perform diagnostic checks whilst identifying potential problems.

(d) Explicitly fit the model for binary and count type data.

(e) Perform statistical analysis using statistical software, incorporating underlying theory and methodologies.

Detailed Syllabus

Measures of association for classified nominal and ordinal categorical data. Generalized Linear Models: Introduction, Components of a GLM, Maximum Likelihood estimation, Deviance.

Binary data and Count data: un-grouped and grouped. Models with constant coefficient of variation. Polytomous data. over dispersion and fitting by quasi-likelihood.

3. **STAT-206C Risk Analysis**

Course Objectives

- Understand the concept of decision problem and two person game.
- Basics of Non-randomized and randomized rules, Risk function, Admissibility of decision rules.
- Know the details of class of non-randomized rules for convex loss.
- Introduction to Bayes' rule and admissibility of Bayes rule.

Learning Outcomes

- Understand the main tools from probability and statistics that are used in modeling and analyzing risk in a business context.
- Become familiar with the relevant tests and tools for carrying out statistical computations.
- Become familiar with the basic concepts and methods of risk analysis.
- Become acquainted with the applications or risk analysis to several domains such as valuation with risk, financial risk minimization, supply chain management, and program management.

Detailed syllabus

Decision Problem and two - person game, Non-randomized and randomized rules, Risk function, Admissibility of decision rules, Complete, essentially complete, minimal complete and minimal essentially complete classes. Essential completeness and completeness of class of rules based on sufficient statistic and the class of non-randomized rules for convex loss. Bayes rules, Extended Bayes, Generalized Bayes and Limit of Bayes rules, Admissibility of Bayes rule. Mini-max rules, Method for finding mini-max rules.

1.4.4 STAT-208 Elective Paper-III

Anyone from the following:

1. **STAT-208A Time Series**

   Linear stationary processes, AR, MA, ARMA and ARIMA; identification, estimation of the models; forecasting time series regression; Fourier analysis, spectral representation of a stochastic process, properties of ARMA processes in the frequency domain; estimation of the spectrum, Kalman filter.

2. **STAT-208B Advanced Data Analytic Techniques**

   Course Objectives

   The main goal of this course is to help students learn, understand and practice advanced data analytic techniques, which include the study and analysis of different types of data: cross sectional and longitudinal data. It aims to expose students to several resampling techniques which are used for handling small samples.

   Learning Outcomes

   After taking this course, students are expected to be highly skilled in handling varied types of datasets and also the datasets where a substantial number of missing points are observed. They will learn Jackknife, bootstrap and other resampling techniques. Several restricted likelihood methods of estimation will also let them aware of handling critical situations. By learning the techniques, the students are expected to excel as an applied statistician (both if they choose a career for pursuing research as well as for joining industry).

   Detailed syllabus

   Resampling Techniques : Introduction to Jackknife and Bootstrap - methods for estimating bias, standard error and distribution function based on iid random variables, standard examples, Bootstrap confidence intervals.

   Missing data analysis : Informative or non-informative missingness, complete case / available case estimation, Imputation, EM & MCEM algorithms and data augmentation techniques. Standard error estimation.

   Longitudinal data analysis : Longitudinal regression, Cohort vs longitudinal effect, Weighted least-squares, ML and REML techniques.

3. **STAT-208C Development Statistics**

Course Objectives

- Understand the role of statistics in National and international statistical systems of economic development.
- Basics of Distribution of income for measurement of poverty and inequality
- Know the details measures of unemployment.
- Basic concepts of development indices.
- Know the different indicators of development.

Learning Outcomes

- Understand the national account system and estimate national and state incomes.
- Project the future populations and the income distribution to eradicate poverty and inequality.
- Calculate different development indices which includes crop-forecasting, crop insurance, procurement, buffer stock management, foreign trade, balance of payments, planning, allocation of resources and evaluation of family welfare programmes.

Detailed syllabus

Concept of economic development - role of statistics. National and international statistical systems. National accounts - estimation of national and state incomes and their components. Projection of populations. Distribution of income - measurement of poverty and inequality. Measures of unemployment.

Development indices. Other indicators of development (includes agriculture - crop-forecasting and estimation, crop insurance, procurement and buffer stock management; foreign trade and balance of payments; planning and allocation of resources; evaluation of family welfare programmes)

1.4.5 STAT-272 Project

1.4.6 STAT-292 Statistical Lab-IV