Department of Statistics
Begum Rokeya University, Rangpur
Syllabus for B.Sc. (Hons.) in Statistics
Session: 2015-2016

The Bachelor of Science (B. Sc.) Honors program in Statistics aims at teaching modern statistical techniques in theoretical, practical and in research sectors particularly with computer intensiveness.

This program is extended over a period of four academic years. Each academic year is divided into two Semesters to be called as 1st Semester (July-December) and 2nd Semester (January-June). The courses offered in this program are of theoretical and practical in nature. For the purpose of assessment, each theoretical and practical course offered should be composed of either 50 or 100 marks. The total credits of courses are 153, which is composed of a total of 5100 marks.

The class attendance carries 5%, assignments carry 10%, quizzes carry 10%, mid-term carries 25% and the semester final carries 50% of the total marks both in theoretical and practical courses. The students shall have to submit a project report carrying 1.5 credits at the end of the eighth semester. The topic of the project report will be approved by the Head of the Department on the recommendation of the research supervisor, which will be submitted on or before the day of the last practical examination. At the end of all course examinations in each academic year students shall have to face an interview board for viva-voce, which carries 1.5 credits. The semester-wise structure for the B.Sc. (Honors) program is given below:

Level	Course Code	Course Title	Marks	Credit Points
1st year 1st Semester	STAT 1101	Principles of Statistics-I	100	3
	STAT 1102	Probability Theory	100	3
	STAT 1103	Linear Algebra	100	3
	STAT 1104	Analytical Geometry and Calculus	100	3
	STAT 1105	Statistical Data Analysis-I (Lab)	50	1.5
	STAT 1106	Statistical Data Analysis-II (Lab)	50	1.5
		Total	**500**	**15**
1st year 2nd semester	STAT 1201	Principles of Statistics-II	100	3
	STAT 1202	Algebra and Numerical Analysis	100	3
	STAT 1203	Mathematical Economics	100	3
	STAT 1204	Introduction to Computers with Task-Oriented Software	100	3
	STAT 1205	Statistical Data Analysis-III (Lab)	50	1.5
	STAT 1206	Statistical Data Analysis-IV (Lab)	50	1.5
	STAT 1207	Statistical Data Analysis-V (Lab)	50	1.5
	STAT 1208	Statistical Data Analysis-VI (Lab)	50	1.5
	STAT 1209	Viva voce	50	1.5
		Total	**650**	**19.5**
2nd year 1st semester	STAT 2101	Regression Analysis and Diagnostics	100	3
	STAT 2102	Probability Distributions	100	3
	STAT 2103	Differential Equations and Complex Variables	100	3
	STAT 2104	Demography	100	3
	STAT 2105	Statistical Quality Control	50	1.5
	STAT 2106	Statistical Data Analysis-VII (Lab)	50	1.5
	STAT 2107	Statistical Data Analysis-VIII (Lab)	50	1.5
	STAT 2108	Statistical Data Analysis-IX (Lab)	50	1.5
		Total	**600**	**18**

2nd year 2nd semester	STAT 2201	Sampling Distribution	100	3
	STAT 2202	Real analysis	100	3
	STAT 2203	Analysis of Variance and Design of Experiments	100	3
	STAT 2204	Computer Programming	100	3
	STAT 2205	Environmental Statistics	100	3
	STAT 2206	Statistical Data Analysis-X (Lab)	50	1.5
	STAT 2207	Statistical Data Analysis-XI (Lab)	50	1.5
	STAT 2208	Viva voce	50	1.5
		Total	**650**	**19.5**
3rd year 1st semester	STAT 3101	Statistical Estimation	100	3
	STAT 3102	Stochastic Processes	100	3
	STAT 3103	Multinormal distribution and Order Statistics	100	3
	STAT 3104	Survey Methods	100	3
	STAT 3105	Operation Research	50	1.5
	STAT 3106	Statistical Data Analysis-XII (Lab)	50	1.5
	STAT 3107	Statistical Data Analysis-XIII (Lab)	50	1.5
	STAT 3108	Statistical Data Analysis-XIV (Lab)	50	1.5
		Total	**600**	**18**
3rd year 2nd semester	STAT 3201	Hypothesis Testing	100	3
	STAT 3202	Time Series Analysis	100	3
	STAT 3203	Econometrics	100	3
	STAT 3204	Statistical Simulation and Data Processing	100	3
	STAT 3205	Statistical Data Analysis-XV (Lab)	50	1.5
	STAT 3206	Statistical Data Analysis-XVI (Lab)	50	1.5
	STAT 3207	Statistical Data Analysis-XVII (Lab)	50	1.5
	STAT 3208	Statistical Data Analysis-XVIII (Lab)	50	1.5
	STAT 3209	Viva voce	50	1.5
		Total	**650**	**19.5**
4th year 1st semester	STAT 4101	Multivariate Distribution	100	3
	STAT 4102	Sampling Techniques	100	3
	STAT 4103	Actuarial Statistics	100	3
	STAT 4104	Categorical Data Analysis	100	3
	STAT 4105	Non-parametric tests	100	3
	STAT 4106	Research Methodology	100	3
	STAT 4107	Statistical Data Analysis-XIX (Lab)	50	1.5
	STAT 4108	Statistical Data Analysis-XX (Lab)	50	1.5
	STAT 4109	Statistical Data Analysis-XXI (Lab)	50	1.5
		Total	**750**	**22.5**
4th year 2nd semester	STAT 4201	Multivariate Analysis-II	100	3
	STAT 4202	Economic Statistics and Econometrics	100	3
	STAT 4203	Epidemiology and Survival Analysis	100	3
	STAT 4204	Data Mining	100	3
	STAT 4205	Statistical Data Analysis-XXII (Lab)	50	1.5
	STAT 4206	Statistical Data Analysis-XXIII (Lab)	50	1.5
	STAT 4207	Statistical Data Analysis-XXIV (Lab)	50	1.5
	STAT 4208	Statistical Data Analysis-XXV (Lab)	50	1.5
	STAT 4209	Project Report	50	1.5
	STAT 4210	Viva Voce	50	1.5
		Total	**700**	**21**
		Grand Total	**5100**	**153**

STAT 1101
Principles of Statistics-I
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Statistics and Its Origin: History, Definitions, Characteristics, Classification, Uses, Importance and Limitations of Statistics, Relation with other Disciplines.

Sources of Statistical Data: Meaning of Data, Primary and Secondary Data (Methods of Collecting Data, Preparation of Questionnaire and Schedule, Pre-Testing of Questionnaire, Data Coding and Code plan.)

Processing and Presentation of Statistical Data: Scales of Measurement: Nominal, Ordinal, Interval and Ratio, Variables and Attributes, Types of Variables, Summarizing and presenting Data, Concept of Frequency Distributions, Presenting Data by Percentage, Proportions, Rates and Ratios, Presenting Data by Graphs and Diagrams ,Stem and Leaf Display.

Measures of Central Tendency & Measures of Location: Meaning of Central Tendency, Mean, Median and Mode with their Properties, Application of the Measures of Central Tendency, Meaning of Measures of Location, Quartiles, Deciles and Percentiles, Geometric Mean and Harmonic Mean with their Properties, Comparing the Averages, Box and Whisker Plots with their Uses.

Measures of Dispersion: Meaning of Dispersion, Absolute and Relative Measures of Dispersion, Empirical Relations among Measures of Dispersions.

Index Number: Basic Concepts, Problem of Index Number, Calculation of Indexes, Errors in Index Number Formulae, Tests of Index Numbers.

Time Series: Meaning of Time Series, Components of Time Series, Secular Trend, Cyclical Variation, Seasonal Variation, Irregular Variation, Moving-average Method, Weighted Moving Average, Linear Trends, Least Squares Method, Non-linear Trends, Determination of Seasonal Index, Deseasonalized Data, Using Deseasonalized Data to Forecast.

References:

1. Douglas A. Lind ,William G. Marchal, Samuel A.Wathen (2012): *Statistical Techniques in Business and Economics,* 15th ed. Irwin.
2. Hoel, P. G. (1976): *Elementary Statistics,* 4th ed. New York, John Willy.
3. Hoel, P. G. (1976): *Elementary Statistics,* 4th ed. New York, John Willy.
4. Kendall, M. G. and Stuart (1984): *An Introduction to the Theory of Statistics.*
5. Kendall, M. G. and G. U. Yule (1969): *An Introduction to the Theory of Statistics,* 14th ed. Charles Griffin, London.
6. Kendall, M. G. and Stuart (1984): *Advanced Theory of Statistics,* 14th ed. Edward Arnold, N. Y.
7. Wonnacott, T. H. and R. J. Wonnacott (1990): *Introductory Statistics,* 5th ed. New York, John Willy.
8. Bulmer M. G. (1979): *Principles of Statistics,* Oliver and Boyd, London.
9. David, F. N. (1971): *A First Course in Statistics,* Charles Griffin, London.
10. Moore, P. G. (1969): *Principles of Statistical Techniques,* C. U. P., London.

STAT 1102
Probability Theory
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Set Theory: Sets and Set Operations, Description and Notations, Universal Set. Venn Diagram, Empty Set, Subsets, Proper Subset, Equal Set, Unit Set, Finite and Infinite Sets, Operations with Sets-Intersection, Union, Complementation, Class of Sets, Power Set, Cartesian Product Set and Differences of Sets, Algebra of Sets-Commutative Laws, Associative Laws, Distributive Laws, Identity Laws, Idempotent Laws, Complement Laws and De Morgan's Laws.

Probability: Probability and Possibility, Experiment or Random Experiment, Basic Requirements of Probability, Sample Space, Events, Probability of an Event, Mutually Exclusive Events, Addition Law, Counting Rules, Methods of Assigning Probabilities**:** The Classical, Empirical, Geometric, Relative Frequency, Axiomatic and Subjective methods, Total and Compound Probability, Probability and Odds, Odds Ratio, Tree Diagrams, Independence and Non-Independence of Events, Conditional Probability, Bayes' Theorem and Applications, Other Aspects of Probability.

Random Variables: Basic Concepts, Discrete and continuous Random Variables, Probability Distribution, Probability Mass and Density Functions, Distribution Functions, Function of a Random Variable, Joint, Marginal and Conditional Distribution, Independence of Random Variable.

Mathematical Expectation: Meaning of Mathematical Expectation, Expected Value of a Function of a Random Variable, Expected Value of a Function of Two Random Variables, Conditional Expectation, Conditional variance, Moments and Moment Generating Function, Cumulants and Cumulant Generating Function, Relations Between Moments and Cumulants, Characteristic Function, Special Mathematical Expectation, Chebyshev's inequality .

Basic Probability Distributions: Uniform, Bernoulli, binomial, Poisson, Normal, Exponential Distributions with applications.

References:

1. Mood, A. M., Graybill and D. C. Boes (1974): *An Introduction to the Theory of Statistics,* 3rd ed. New York: McGraw-Hill.
2. Meyer, P. L. (1970): *Introductory Probability and Statistical Applications,* 2nd ed. New Delhi: Oxford and IBH.
3. Mosteller, Rourke and Thomas (1970): *Probability with Statistical Applications,* 2nd ed. London: Addison-Wesley.
4. Hogg R. V. and A. T. Craig (2002): *Introduction to Mathematical Statistics,* 6th Edition, Pearson Education (Singapore) Pte Ltd.
5. Ross, S.M. (2002): *Introduction to Probability Models,* 3rd ed, Academic Press, N.Y. Lipschutz, S. (1987): Probability, McGraw-Hill, N.Y.
6. Chung, K. L. (1979): *Elementary Probability Theory with Stochastic Process,* 3rd ed. Springer - Verlag, N.Y.
7. Cramer, H. (1955): *The Elements of Probability Theory,* Wiley, N.Y.
8. Feller, W. (1985): *Introduction to Probability Theory and Its Applications,* Vol.1, 3rd ed., Wiley, N.Y.
9. Lindley, D.V (1965): *Introduction to Probability and Statistics,* Vol. 1, C.U.P., London
10. Lipschutz, S. (1964): *Set Theory,* McGraw-Hill, N.Y.

11. Lukacs, E. (1972): *Probability and Mathematical Statistics: An Introduction,* Academic Press, N.Y.
12. Parzen, E. (1992): *Modern Probability Theory and Its Applications,* Wiley, N.Y.
13. Ross, S.M. (1987): *Introduction to Probability and Statistics for Engineers and Scientists.*

STAT 1103
Linear Algebra
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Vectors: Addition and Scalar Multiplication, Vector product, Geometrical Interpretation of Vector, Linear Dependence and Independence, Vector Space, Basis and Dimension, Sub-space, Cauchy-Schwartz inequality.

Matrices and Determinants: Definition of matrices, Matrix Operations and their Properties, Different types of Matrices, Identity matrix, Scalar, Diagonal, Null, Symmetric, Skew-Symmetric, Orthogonal, Unitary, Hermitian and Skew-Hermitian, Idempotent, Nilpotent and Involuntary matrices, Variance-covariance and Correlation matrices, Trace of a matrix, Definition of determinant, properties of determinant , Ideas of Minors, cofactors, Product of determinants, Solution of equation with the help of Determinants, Rank of matrices and their properties and related theorem, Partitioning of matrices, Ad joint, Inverse and generalized inverse of a matrix and their properties.

Simultaneous Equations: Introduction, Solution of systems of homogeneous and non-homogeneous equations, Cramer's rule.

Characteristic values problems and quadratic forms: Characteristic Roots and Vectors of a matrix, related theorem of Characteristics Roots and vectors, Caley-Hamilton theorem, Quadratic form and their Classifications, Their identification, Diagonalization of quadratic form, Related theorem of Quadratic forms, Gram Schmidt, Orthogonalization, Diagonalization of General Symmetric Matrices, Spectral Decomposition and Singular Value Decomposition of Matrices.

References:

1. Basilevsky, A. (1982): *Schaum's Outline of Theory and Probability of Matrices*, Singapore, McGraw-Hill (Schaum's Outline Series).
2. Graybill, A. (1982): *Matrices with Application in Statistics*, Wadsworth & Co.
3. Hadley, G. (1993): *Linear Algebra*, Addison Wesley Company, N.Y.
4. Searle, S. (1982): *Matrix Algebra Useful for Statistics*, Wiley, N.Y.
5. Ali, M. I. (1984): *Matrices and linear transformations*, Iman's Mathematical Publisher, Dhaka.
6. Lipschutz, S. (1987): *Theory and Problems of Linear Algebra*, Sl (metric) edition, McGraw-Hill book co., Singapore.
7. Narayan, S., *A text book of Matrices*, S. Chand and Co., New Delhi, 1985.

STAT 1104
Analytical Geometry and Calculus
Full Marks-100
No. of Lectures: Minimum-30.
Duration of each lecture: 1.5 hours
Duration of Examination: 3 Hours.

Analytical Geometry: Basic concepts of Cartesian and Polar Co-ordinates, Pythagorean distance formula, Conic section.

Functions: Function and Relation, Domain, Range, Inverse Function and Graphs of functions like exponential, logarithmic, sine, tangent etc. limits, continuity, and indeterminate form.

Ordinary Differentiation: Differentiability, Differentiation and Successive Differentiation, Leibniz theorem.

Expansions of Functions: Rolle's Theorem, Mean Value Theorem, Taylor's and Maclaurin's Formulae, Maxima and Minima of Functions.

Partial Differentiation: Euler's theorem, Tangents and Normal. Asymptotes. L' Hospitals rule.

Indefinite Integrals: Method of substitution, Integration by parts, Special trigonometric functions and rational fractions.

Definite Integrals: Fundamental theorem, General Properties. Evaluations of Definite Integrals and Reduction Formulae, Ideas of Double Integral, Triple Integral, Gamma function Beta function.

References:

1. Anton, H (2000): *Calculus with Analytic Geometry*, Wiley, N.Y.
2. Ayres, F. (1982): *Calculus*, McGraw-Hill, N. Y.
3. Stewart, J. (2003): *Calculus: Early Transcendentals* (5th Ed.) Brooks/Cole, N.Y.
4. Binmore, K.G. (1983): *Calculus*, CUP, London.
5. *Buck, R. C. (1977): Advanced Calculus,* 3 rd ed. McGraw - Hill, N.Y.
6. Edwards, J, (1994): *Differential Calculus*, Macmillan, London
7. Lang, S. (1988): *First Course in Calculus*, 5th ed., Springer-Verlag, N.Y.
8. Maxwell, A.E. (1957): *An Analytical Calculus*, Part I Et II, C.U.P., London
9. Meldelson, E. (1988): *Calculus*

STAT 1105
Statistical Data Analysis-I (Lab)
Full Marks-50
No. of Lectures: Minimum-15.
Duration of each lecture: 1.5 hours
Duration of Examination: 2 Hours.

Collection of simple data on at least two continuous and two qualitative variables by individual student, Construction of frequency distribution tables with Equal and Unequal Class Intervals, Graphical Representation, computation and interpretation of various measures of central tendency and dispersion from ungrouped and grouped data, calculation of moments, Sheppard's Corrections for Grouping Error, calculation of Skewness and Kurtosis, steam and leaf plots, box and whisker plots, Fitting of probability distributions-Uniform, binomial, Poisson, Normal, Problems related to Time Series and Index Number.

STAT 1106
Statistical Data Analysis-II (Lab)
Full Marks-50
No. of Lectures: Minimum-15.
Duration of each lecture: 1.5 hours
Duration of Examination: 2 Hours.

Matrix Addition, Substraction and Multiplication, Rank of a matrix, Transpose, Determinant and Inverse, Solution of simultaneous equation, Characteristic roots and characteristic vector, Quadratic form, Inverse by partition method, Generalized inverse.

STAT 1201
Principles of Statistics-II
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Correlation: Preparation of Bivariate frequency distribution, Correlation Ratio, Rank Correlation, Spearman Rank correlation, Kendall's Tau Correlation and Coefficient of Concordance, Fourfold and Tetra Choric Correlation, Intra-Class Correlation, Serial and Biserial Correlation, Partial and Multiple Correlation, Spurious Correlation, Non-sense Correlation,

Regression: Review of Regression, Standard error of estimates, Properties, Confidence interval & Hypothesis test in simple Regression, Lines of Best Fit, Residual Analysis and Linearity of Regression.

Analysis of Attributes: Basic Ideas, Classification, Order of Classes and Class Frequencies, Ultimate Class Frequencies, Positive Attributes, Consistency, Incomplete Data, Association of Attributes, Independence, complete association and disassociation, Measures of association, Coefficient of association, Coefficient of colligation, Partial association, Contingency Table, Coefficient of Contingency, Pearson's Coefficient of Mean Square Contingency, Analysis of $r \times c$ Contingency Table, Analysis of 2×2 Contingency Table by Yate's Correction.

Shape Characteristics of Distribution: Moments of a distribution, Sheppard's Correction for Moments, Shape Characteristics of a Distribution-Skewness and Kurtosis.

Bivariate Distributions: Concept of Bivariate Probability Distribution, Marginal and Conditional Distribution, Expected Values and Variances, Moments and Cumulants, Moment and Cumulant Generating Functions, Derivation of Bivariate Normal Distribution and Study of its Properties, Normal Regression.

References:

1. Hogg and Tanis (2001): *Probability and Statistical Inference,* 6th ed. Prentice Hall, N.J.
2. Wonnacot, T. H. and Wonnacot, R. J. (1990): *Introductory Statistics,* 3rd ed. Wiley, N. Y.
3. Yule, G. U. and Kendall, M. G. (1994): *An Introduction to the Theory of Statistics,* 14th ed. Charles Griffin, London

4. Anderson, A.J.B (1989): *Interpreting Data,* Chapman and Hall, London
5. Bulmer M.G. (1979): *Principles of Statistics,* Oliver and Boyd, London
6. David, F.N (1971): *A First Course in Statistics,* Charles Griffin, London.
7. Hoel, P.G. (1993): *Introductory Statistics,* Wiley, N.Y.
8. Kendall, M.G. and Stuart, A. (2004): *Advanced Theory of Statistics,* 14th ed. Edward Arnold, N.Y.
9. Lindley, D.V. (1965): *Introduction to Probability and Statistics,* Part-1, C.U.P., London
10. Moore, P.G. (1969): *Principles of Statistical Techniques,* C.U.P., London
11. Spiegel, M.R. (1971): *Statistics,* McGraw-Hilt, N.Y.
12. Wolf, F. L. (1974): *Elements of Probability and Statistics,* McGraw-Hill, NY.

STAT 1202
Algebra and Numerical Analysis
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Basic Concepts of Algebra: Concepts of Equation, Binary Relation, Operation, Equivalence Relation, Properties of Real Numbers and complex numbers, Definition of Group and Field.

Theory of Equations: Theory of Equations, Binomial and Polynomial Equations, the Remainder Theorem in Algebra, Multiple Roots, Relation Between Roots and Coefficients, Des Carte's Rule of Signs, Symmetric Function of the Roots, Solutions of Cubic and Bi-Quadratic Equations.

Differences: Differences of Polynomials, Concept of Interpolation and Extrapolation, Finite Difference Operator, Difference Table, Difference Equations, Newton's Interpolation Formula.

Central Difference Formula: Gauss Formula, Stirling's Formula and Bessel's Formula with Equal and Unequal Interval of the Argument.

Divided Difference Formula: Newton's General Interpolation Formula, Lagrange's Formula.

Inverse interpolation: Lagrange's Formula, Newton's Divided Interpolation Formula, Successive Approximations and Reversion of Series.

Extrapolation: Different methods of extrapolation.

Numerical differentiation and Integration: General Quadrature Formula, Simpson's Rule, Weddle's Rule, Trapezoidal Rule.

Solution of Equations: Numerical Solution of Equations by Various Methods (Method of False Position, Newton-Rapson Method and Method of Iteration), Convergence of these Methods and Their Inherent Errors, Numerical Solution of Simultaneous Linear Equations by Different Methods, Numerical Solution of Ordinary Differential Equations of First Order and of Second Order.

References:

1. Kuo, S. S. (1972): *Computer Applications of Numerical Methods Reading,* Addision-Wiley.
2. Scarborough, J. B. (1966): *Numerical Mathematical Analysis,* 6th ed. Johns Hopkins Press, Baltimore.

3. Scheld, F. (1988): *Schaum's Outline of Theory of Problems and Numerical Analysis,* McGraw Hill, Singapore.
4. Sastry, S. S. (1995): *Introductory Methods of Numerical Analysis,* 2nd ed. New Delhi, Prentice-Hall.
5. Ayres, F. (1965): *Theory and Problems of Modern Algebra,* Schaum's Outline Series, McGraw-HiL1. Book Company.
6. Comte, S. D. and C de Boor (1981): *Elementary Numerical Analysis,: An Algebraic Approach,* 3rd ed. McGraw-Hill.
7. Hildeerbrand (1984): *Introduction to Numerical Analysis.*
8. Littlewood, D. E. (1977): *University Algebra,* Oxford University Press, Oxford
9. Van Der Waerden, BL (1966): *Modern Algebra,* Frederick Ungar publishing Co., New York.

STAT 1203
Mathematical Economics
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Introduction: Meaning of Economics, Macroeconomics and Microeconomics, Goals of Microeconomics and Macroeconomics, Positive and Normative economics, common Fallacy of Economics, Methodology of economics, the economic Problem, and the Circular Flow of Economic Activity.

Demand and Supply: Concept of demand and supply, Ceteris Paribus Theory, Market Price Determination under Pure Competition, Equilibrium Theory, Shits in Demand and Supply, Effects of Sales Tax and Specific Tax on Purely Competitive Equilibrium, Demand and Supply as Functions of More than One Variable, Complementary Product and Substitute Product.

Elasticity: Demand and Supply Elasticity, Demand and Total Revenue, Elasticity and Marginal Revenue, Elasticity Properties, Elasticity of Market Demand, elasticities for Functions of Several Variables.

Theory of Consumer Choice: Total and Marginal Utility, Law of Diminishing Marginal Utility, Maximizing Utility, Marshallian Cardinal Utility Approach, Hicksian Ordinal Utility Approach, Consumer Equilibrium, Substitution and Income Effects and Slutskey Equation Revealed Preference Theory.

Indifference Curve Approach: Indifference Curve, Indifference Map, Properties of Indifference Curve, Marginal Rate of Substitution, Budget Constraint, Substitute and Income Effect.

Theory of Production: Production with One Variable Input: Total, Average and Marginal Product, Stages of Production Law of Return to Scale, Production with Two Variables Inputs: Isoquant Curve, Characteristics of Isoquant Curves, Marginal Rate of Technical Substitution, Producer's Equilibrium.

Cost of Production: Explicit and Implicit Costs, Various Measures of Cost, Costs in Short Run and in Long Run.

Market Structure: Perfect Competition: Concept of Competitive Market, Profit Maximization and Competitive Firm's Supply Curve, Supply Curve in Competitive Market,

Monopoly: Production and Pricing Decisions, Monopoly Profit Maximization using Production Functions,, Price Discrimination, the Multiple Plant Monopolist, the Multiple Product Monopolist, Taxing the Monopolist, Revenue Maximization, Monopolistic Competition: Monopolistically Competitive Firm in Short Run and in Long Run. **Oligopoly:** Profit Maximization under Oligopoly Assuming Collusion, Dominant Firm Leadership, Fixed Market Shares, the Giant Corporation.

Measuring the Value of Economic Activity: Gross Domestic Product (GDP), Income, Expenditure, Circular Flow, Rules for Computing GDP, Components of Expenditure, Nominal GDP versus Real GDP, GDP Deflator, GDP and Economic Well-being, Other Measures of Income. **Measuring Cost of Living:** Consumer Price Index (CPI), CPI Versus GDP Deflator.

Money and Inflation: Functions of Money, Types of Money, Measures of Money Stock, Banks and Money Supply, Quantity Theory of Money, Inflation and Interest Rates, Expected and Unexpected Cost of Inflation.

Short-Run Economic Fluctuations: Aggregate Demand and Aggregate Supply Curves, Two Causes of Economic Fluctuations, Influence of Monetary Policy and Fiscal Policy on Aggregate Demand.

References:

1. Blanchard, Olivier (2011): *Macroeconomics Updated* (5th ed.). Englewood Cliffs: Prentice Hall.
2. Bouman, John (2011): *Principles of Macroeconomics – free fully comprehensive Principles of Microeconomics and Macroeconomics texts*. Columbia, Maryland.
3. Bressler, B. (1960): *A unified introduction to mathematical economics,* Harper & Row publishers.
4. Diulio, E. (1997): *Macroeconomics*, Shaums outline series, 3rd edition.
5. Heijdra, B. J.; Ploeg, F. van der (2002), *Foundations of Modern Macroeconomics*, Oxford University Press.
6. N. Gregory Mankiw (2008): *Principles of Macroeconomics*, 6th Edition.
7. Roy, J. and Ruffin and P.R. Gregory (1983): *Principals of Economics.*
8. Todaro, M. (1993): *Economics for a Development World,* 4th ed. Orient Longman.
9. Wonnacott, Paul and Wonnacott Ronald (1982): *Economics.*
10. Dominick Sulvatore (1992): *Theory and problems of Microeconomic theory,* 3ed ed. McGraw Hill, N.Y.
11. Roy, J. and Ruffin and P.R. Gregory (1983): *Principals of Economics.*
12. Wonnacott, Paul and Wonnacott Ronald (1982): *Economics.*

STAT 1204
Introduction to Computers with Task-Oriented Software
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Introduction: Simple Model of a Computer, Characteristics of a Computer, Problem Solving Using Computers.

Classification: Super Computers, Mainframes, Personal Computers, Notebook Computers, Personal, Digital Assistants.

Input: Keyboard, Mouse, Trackball, Source of Data Automation: Collecting Data Where it Starts, Magnetic-ink Character Recognition, Scanner, Voice Input, Touch Screens.

Output: Computer Screen Technology, Flat Screens, Terminals, Printers, Voice Output, Music Output and Sounds.

Computer graphics: Business Graphics, Video Graphics, Computer-Aided, Design/Computer-Aided, Manufacturing and Digital Cameras.

The central processing unit: The Control Unit, the Arithmetic/Logic Unit, Registers: Temporary Storage Areas.

Memory: How the CPU Executes Program Instructions, Storage Locations and Address, How the Control Unit Finds Instructions and Data.

Personal computer chips: Microprocessors, Memory components.

Data Representation and Number System: Bits, Bytes and words, Coding Schemes: Binary, Hexadecimal and Octal Representation of Numbers, Speed and Power Computer Processing Speeds, Bus Lines, Cache and Flash Memory.

Secondary Storage: Magnetic Disk Storage: Diskettes, Hard Disks, Hard Disks in Groups, Floppy Disk Drives, Organization of Data on a Disk, Optical Disk Storage: CDROM, DVDROM, Multimedia: Multimedia Requirements, Multimedia Applications, Magnetic Tape Storage: Backup Systems.

Software: Applications Software, Task-Oriented Software: Word Processing/Desktop Publishing, Electronic Spreadsheets, Database Management, Graphics, Communications, Office Suites, Business Software and Hidden Software.

Operating System: Meaning of a Computer Operating System, Types of Operating System, Batch Operating system, Multiprogramming Operating System, Sharing Operating System.

Microsoft Windows Operating System: Starting Windows, Understanding Windows Components, Starting Programs, Moving and Closing Windows, Switching Between Programs, Restarting and Shutting Down Windows.

Managing Files and Folders: Viewing and Opening Folders, Opening, Editing and Saving Files, Printing a File, Sorting Files, Creating Files and Folders, Moving, Copying and Renaming Files and Folders, Deleting Files and Folders.

Searching for Files and Folders: Searching by Name, Searching for Files that Contain Specific Test and Searching for Files of the Criteria.

Customizing Desktop: Creating Shortcut Icons on the Desktop, Arranging Icons on the Desktop, Changing the Appearance of The Desktop, Adding Active Desktop Items, Changing Mouse's Properties, Customizing the Start Menu, Customizing the Task Bar.

Networking: Meaning of Networking, Data Communication and Its Types, Basic Components of Data Communication System, Communication Link, Modulation and Demodulation, Router, Data Transmission and Its Types, Network Topologies, Types of Network - LAN, WAN, MAN, etc., Some Commonly Used Protocols, TCP/IP.

Internet: Basic Concept, Uses and Structure of Network, Server, Browser, How Internet Works, Factors Required to Run Internet, ISP, Features of Browser, Browser Launching, URL, Navigating Web, Search Engine.

Electronic Spreadsheet (MS Excel): Meaning of Spreadsheet Software, Spreadsheet Software's Interface, Entering Data in Worksheet, Editing and Formatting Worksheet.

Word Processing: Word Processing Programs and their Uses, Word Processor's Interface, Entering and Editing Text, Formatting Text, Document Formats, Formula and Function Management, Creating Tables, Desktop Publishing Software.

Power Point Presentation*:* Meaning and Use of Presentation Programs, Presentation Program's Interface, Creating Presentation, Formatting Slides.

Database Software: Basic Concept, Functions of Database Software, Working with Database, Primary Key and Foreign Key, Types of Relationships: One-to-One, One-to-Many and Many-to-Many, Constructing Tables, Forms, Queries, Reports.

E-mail and Macro Virus: Basic Idea of E-mail, Concept of Macro Viruses, Affect of Virus in Computer, Categories of Viruses, Preventing Infections, Idea about Antivirus, Firewall.

References:

1. Rajaraman, V., (1999): *Fundamentals of Computers,* Prentice-Hall.
2. Courter, G. and Marquis, A., (1999): *Mastering Microsoft Office 2000.*
3. Gallo, A M., (1985): *Computers and Society,* Prindle.
4. Blattner, P. and Ulrich, L. (2000): *Microsoft Excel 2000,* Prentice-Hall, India.
5. John A. Rafter, Jame Brasetton, Martha Abell (2003): *Statistics with Maple*, Springer-Verlag, New York.
6. Kroenke, David M., and David J. Auer (2007): *Database Concepts,* 3rd ed. Prentice, New York.
7. Kroenke, David M. (1997): *Database Processing: Fundamentals, Design, and Implementation,* Prentice-Hall, Inc.
8. Michael Kotler (2000): *Maple: An introduction and reference,* Addison-Wesley Longman Publishing Co., Inc. Boston, MA, USA

STAT 1205
Statistical Data Analysis-III (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Collection of simple data on at least two continuous and two qualitative variables by individual student, Preparation of scatter diagram showing all types of relationship between two variables, Preparation of Bivariate frequency table and computation of conditional means and conditional variances and drawing their graphs, Analysis of marginal distributions, Computation of all types of Correlation coefficients, Association , Independency, Consistency and Contingency analysis of attributes, Obtaining normal equations from a system of linear equations and their most plausible solution, Fitting of two and three variables regression models by the method of Least squares when the models are linear in parameters and linear in variables, Computation of partial and multiple correlation and regression coefficients and their interpretation-Three Variable Case, Residual analysis.

STAT 1206
Statistical Data Analysis-IV (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Newton's Forward and Backward Interpolation Formulae, Lagrange's Formula, Newton's General Interpolation, Numerical Integration (Simpson's, Weddle's, Trapezoidal, Euler's Rules), Newton-Rapson Method, Method of False Position, Method of Iteration, Solution of Numerical Equations: Graphical Method, Bisection Method, Iteration Method, Repeated Plotting Large Scale, Method of False Position, Newton-Rapson Method and Muller's Method.

STAT 1207
Statistical Data Analysis-V (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Problems Related to Course STAT 1203.

STAT 1208
Statistical Data Analysis-VI (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Problems Related to Course STAT 1204.

STAT 2101
Regression Analysis and Diagnostics
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Simple Linear Model: Linear and Non-Linear Model, Regression Function and Model Building, Linear Regression, Least Square Estimators and Their Properties, Precision of the Estimated Regression Model, ExaMining Regression Equation, Lack of Fit and Pure Error, Inverse Linear Regression.

Multiple Regression Model: Repeated Observations, Test of Linearity, Non-Linear Relations, Transformation of Variables, Three Variable Regression and Its Parameters' Estimation, Multiple Correlation Coefficient, Correlation Ratio, Inter and Intra-Class Correlation, Confidence Interval, Testing Hypothesis in Three Variable Regression Situation, General Linear Regression Model and Its Parameters' Estimation Using Ordinary Least Square Method (OLS), Properties of OLS Estimators, Orthogonal Columns in $X-$Matrix, Families of Transformations, Use of Dummy Variables in Multiple Regression, Confidence Interval, Testing Hypothesis in General Regression Situation, Weighted Least Squares, Restricted Least Squares, Errors in Predictors (as well as in Response), Inverse Regression (Multiple Predictors Case).

Polynomial Regression: Polynomial Regression, Estimation and Interpretation of Coefficients.

Examination of Residuals: Overall Plot, Time Sequence Plot, Plot against Regression Equation, Plot against Predictor Variables, Other Residual Plots, Statistics for Examination of Residuals, Correlations among Residuals, Outliers, Serial Correlation in Residuals, ExaMining Runs in Time Sequence Plot of Residuals, Durbin-Watson Test for a Certain Type of Serial Correlation, Detection of Influential Observations.

Selection of Best Regression Equation: All Possible Regression, Best Set of Regression, Backward Elimination Procedure, Stepwise Regression Procedure, Ridge Regression, Predictor Sum of Squares, Principal Component Regression, Latent Root Regression, Stage-Wise Regression Procedure, Robust Regression.

Non-linear Estimation: Least Squares in Non-linear Case, Estimating Parameters of Non-linear System, Re-parameterization of Model, Geometry of Linear Least Squares and Non-linear Least Squares, Non-linear Growth Models.

References:

1. Birkes, D. and Dodge, Y. (1993): *Alternative Methods of Regression*, Wiley, Interscience, New York.
2. Bobke, P. (2001): *Correlation and Regression*, 2nd edition, Sage Publication, Thousand Oaks, California.
3. Chatterjee, S. and Price, B. (1977): *Regression Analysis by Examples*, Wiley.
4. Draper, N. R. and Smith, H. (1998): *Applied Regression Analysis*, 3rd edition, Wiley, USA.
5. Johnston, J. (1997): *Econometric Methods*, 4th edition, McGraw-Hill, New York.
6. Koutsoyiannias, A. (1986): *Theory of Econometrics*, 2nd edition, MacMillan, USA
7. Montgomery, D. C. and Peek, E. (1992): *An Introduction to Regression Analysis*, 2nd edition, Wiley, New York.
8. Neter, J. B. and Wasserman, J. D. (1982): *Applied Statistical Linear Models*, 2nd edition, Allion and Becon, Canada.
9. Weisberg, S. (1985): *Applied Linear Regression*, 2nd edition, John Wiley, New York.

STAT 2102
Probability Distributions
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Probability Space, Probability Calculus, Measure Theoretical Approach to Probability, Concept of Family of Exponential Distributions.

Univariate Discrete Distributions: Detailed Study of Bernoulli, Rectangular, Geometric, Hypergeometric, Negative Binomial, Multinomial, Logarithmic, Beta-binomial, Family of Hypergeometric, Generalized Negative Binomial.

Univariate Continuous Distributions: Detailed Study of Uniform, Normal, Beta, Gamma, Exponential, Half Normal, Log Normal, Cauchy, Weibull, Inverse Gaussian, Laplace, Gumbell, Maxwell, Erlang, Pareto and other Exponential Family, Pearsonian System of Curves.
Ehranfaster Model, Contagious, Truncated and Mixture Distribution of Normal, Poisson and Binomial.

Bivariate Distribution: Binomial, Poisson, Hypergeometric, Normal, Gamma, Beta.

References:

1. Devore, J. L. (2002): *Probability and Statistics for Engineering and Sciences*, 5th edition, Thomson Books/Cole, USA.
2. Evans, M., Hasting, N. and Peacock, B. (2000): *Statistical Distributions*, 3rd edition, Wiley, New York.
3. Hogg, R. V. and Craig, A. T. (2002): *Introduction of Mathematical Statistics*, 5th edition, Pearson Education, Asia.
4. Johnson, N. and Balakrishrnan, N. (1994): *Continuous Univariate Distribution*, 2nd edition, John Wiley and Sons, New York.
5. Johnson, N., Kotz, S. and Kemp, A. (1994): *Univariate Discrete Distributions*, 2nd edition, John Wiley and Sons, New York.
6. Kotz, S., Balakrishnan, N. and Johnson, N. L. (2000): *Continuous Multivariate Distributions*: Models and Applications, Vol. 1, 2nd edition, Wiley, New York.
7. Meyer, P. L. (1970): *Introductory Probability and Statistical Applications*, 2nd edition, Oxford and IBH, New Delhi**.**
8. Mood, A. M., Graybill, F. A. and Boes, D. C. (1974): *Introduction to the Theory of Statistics*, 3rd edition, Tata McGraw-Hill, New Delhi.

STAT 2103
Differential Equations and Complex Variable
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Differential Equations: Definition, classification, origin and application, Initial-value and boundary-value problems, Ordinary differential equations of the first degree, Separation of variables, Exact equations. Homogenous equations, Linear equations, Homogenous linear equation with constant coefficients, first order but higher degree differential equations.

Fourier Transformation & Laplace Transformation: Introduction to Discrete & Continuous Fourier Transformation, Necessary Applications Definition and elementary properties, Translation and change of scale, Inverse transform. Transform of derivatives, Convolution theorem, Differentiation and integration of transform.

Complex Variables: Complex number, functions, limit and continuity, Complex differentiation and Cauchy Riemann equations, Complex integration, Cauchy's integral theorem, Morera's theorem, Lowville's theorem, Rouches's theorem, Taylor's theorem, Laurent's theorem, the residue theorem., Evaluation of integrals, Elementary conformal, transformations, Characteristic functions.

References:

1. Ayres, F. (1997): *Differential Equations*, McGraw-Hill, NY.
2. Churchill, V. (1949): *Introduction to Complex Variables and Applications*, McGraw- Hill, N.Y.
3. Holl, Maple and Vinograde (1959): *Introduction to the Laplace Transform*, Appleton-Century, N.Y.
4. Phillps, L.G. (1961): *Functions of a Complex Variable*, Oliver and Boyd.
5. Ross, S.L. (1989): *Differential Equations*, 4th Ed., Wiley, N.Y.
6. Rudin, W. (1976): *Real and Complex Variables*, McGraw-Hill, N.Y.
7. Spiegel, M.R. (1981): *Complex Variables*, McGraw-Hill, N.Y.
8. Widder, D.V. (1989): *Advanced Calculus*, 2nd Ed. Prentice-Hall, N.Y.

STAT 2104
Demography
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Introduction: Definition, Population Studies, Aims and Objectives of Population Studies, Demography and Population Studies, Relationship between Demography and Other Disciplines, Sources of Demographic Data, Methods of Demographic Data Collection, Concept of De Facto and De Jure Population, Assessment of Quality of Demographic Data, Characteristics of Adequate Population Census, Vital Registration Method and Sample Surveys and their Advantages and Disadvantages, Characteristics of Demography, Age and Sex Composition structure, Population aging, Evaluation of Age and Sex data, Myer's index, Whipple's index, UN Age-Sex Accuracy index.

Errors in Demographic Data: Sources of Type of Errors in Demographic Data and their Correlations, Age Heaping, Age Misstatement, Under Enumeration, Over Count etc., Application of Different Methods in Detecting Errors/Digital Preferences, Estimation Method of Under Count and Over Count.

Analysis of Demographic Events: Nature of Demographic Events, Analysis of Fertility, Fecundity, Fecundabality and Reproduction, Various Measures of Fertility, Important Determinants of Fertility, Estimation of Mean Age at Childbearing, Concept of Mortality and Morbidity, Important Determinants of Mortality, Various Measures of Mortality and Morbidity, Force of mortality, Adjusted Measures of Morbidity, IMR and Its Components (Neonatal and Post-Neonatal Infant Mortality), Marriage, Divorce and Nuptiality, Migration.

STATndardization: Concept of Standardization in Demographic Measurements, Role of Standardization, Different Methods of Standardization with their Merits and Demerits, Stable Population and Its Properties, Lotke's and Derivation of Stable Population Model.

Life Table Analysis: Life Table and Its Uses, Current and Cohort Life Table, Construction of Life Table, Life span and Life Expectancy, Applications of Life Tables in Population Studies, Model Life Tables, Study of Stationary, Stable and Quasi Stable Population Models, Graduation of Fertility and Mortality.

Population Projection and Estimates: The nature of Population Estimates and Projection, Methodology of Estimates and Projection, Evaluation of the Methods, Projection of Households and Families and Economically Active Population.

References:

1. Bangladesh Bureau of Statistics (2003): *1981, 1991, 1993, 2001 Bangladesh Population Census Report,* Bangladesh.
2. Biswas, S. (1988): *Stochastic Process in Demography and Applications*, Wiley Eastern, New Delhi.
3. Bogue, D. J., Arraga, E. E. and Anderton, D. L. (1993): *Readings in Population Research Methodology*, Vol. I-V, United Nations Population Fund, Chicago, USA.
4. Everit, B. S. (1996): *The Cambridge Dictionary of Statistics in the Medical Sciences*, Cambridge University Press, UK.
5. Hans Raj (1988): Fundamentals of Demography.
6. Misra, B. D. (1980): *An Introduction to the Study of Population*, South Asia, New Delhi.
7. Pressat, R. (1988): *The Dictionary of Demography,* Blackwell, UK.
8. Ramakumar, R. (1986): *Technical Demography*, Wiley Eastern, New Delhi.
9. Robert, L. B. (1993): *Introduction to the Mathematics of Demography*, 2nd edition, Aetex Publications, Winsted, USA.

10. Shryock, H. S. (1976): *The Methods and Materials of Demography*, Academic Press, New York.
11. Spiegelman, M. (1968): *Introduction to Demography,* Harvard University Press, USA.
12. United Nations (1990): *Step by Step Guide to the Estimation of Child Mortality, Population Studies*, No. 107, USA.
13. UNO (1967): *Methods of Estimating Basic Demographic Measures from Incomplete Data Manual-IV,* Department of Economic and Social Affairs, Population Studies, No. 42, New York.
14. William, B. (1975): *Methods for Estimating Fertility and Mortality from Limited and Defective Data,*Chapel Hill, University of North Carolira Press, London.

STAT 2105
Statistical Quality Control
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Statistical Quality Control: Basic Ideas behind Manufacturing Process, Meaning of Statistical Quality Control (SQC), Process Control and Product Control, Causes of variation in Quality Product, Basic Principles of Quality control, The Control Chart Technique, Various Attribute and Variable Control Charts, Acceptance Sampling and Sampling Inspection, Sampling versus Screening. Sampling Plans, Single, Double, Multiple and Continuous Sampling Plans, OC, ASN, AOQ, AQQL and other characteristics of Sampling Plans.

References:

1. Banks, J. (1989): *Principles of Quality Control*, John Wiley and Sons, New York.
2. Burr, J. (2002): *Elementary Statistical Quality Control*, Marcel Dekkar, USA.
3. Duncan, A. J. (1970): *Quality Control and Industrial Statistics*, 3rd edition, Richard D. Irwin, Homewood, Illinoy.
4. Garrett, H. E. (1958): *Statistics in Psychology and Education*, Vakits, 5th edition, New York.
5. Goon, A. M., Gupta, M. K. and Dasgupta, B. (1972): *Fundamentals of Statistics*, Vol. II, The World Press Private Ltd., India.
6. Grant, E. L. (1996): *Statistical Quality Control*, 7th edition, McGraw-Hill, New York.
7. Montgomery, D. C. (2002): *Introduction to Statistical Quality Control*, 4th edition, John Wiley and Sons, New York.
8. Mukhopadhyaya, P. (1999): *Applied Statistics*, Books and Allied (P) Ltd., India.

STAT 2106
Statistical Data Analysis-VII (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

OLS estimation of general linear regression model, Fitting of polynomial regression model, orthogonal polynomial, Regression with dummy independent variables, Detection of heterosecdasticity and GLS estimation of the model, Detection of autocorrelation and remedial measures, Variable selection and model building.

STAT 2107
Statistical Data Analysis-VIII (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Presentation of Population and Demographic Data by Graphs and Charts, Computations of Population Change and Growth rates, Analysis of Age and Sex Data, Computation of Aging Indices, Evaluation of Age and Sex Data by Whipple's, Myer's and UN Age Sex Accuracy Indices, Analysis of Marital status Distribution, Marriage and Divorce Rates, Computation of different Measures of Fertility and Reproduction from vital registration and census data (such as CWR, CBR, ASFR, ASMFR, TFR, GFR, GRR, NRR and PPR), Computation of Different measures of Mortality CDR,ASMR, IMR, Neonatal, Perinatal death rates Standardization of Birth, Death, Marriage and Divorce Rates, Construction of Complete and Abridged life Tables, by different Methods, Computation, of Migration Rates, Estimates of Migration by survival methods, Population Estimates & Projection using Mathematical Methods.

STAT 2108
Statistical Data Analysis-IX (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Construction of Variable control charts and attribute control charts , Estimation of OC, ASN and AOQ for single and Double Sampling Plans and to find the AOQL for the plans, Determination of the Sampling plans for given values of fraction defective.

STAT 2201
Sampling Distribution
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Distribution of y=g(x), probability integral transformation, Transformation of variables, Standard errors, Random Variable, Distribution of Random Variable, Properties of Random Variable, Functions of Random Variable, Concept of Sampling Distribution, Methods of Obtaining Sampling Distribution, Variate Transformations: Square Root, Log, Sin Inverse, Fisher's Z Transformation.

Drawing Samples from Binomial, Poisson and Normal Distributions, Laplace Transformation, Exact Sampling Distribution Related to Normal Population, Distribution of Sample Mean, Sample Variance, Sample Covariance; Distribution of t, χ^2 and F Statistics, their Properties and Applications. Distribution of Sample Correlation and Regression Coefficients, Joint Distribution of Sample Correlation Coefficient and Covariances, Fisher's Z Distribution.

Theory of Large Samples, Convergence of Random Variable, Modes of Convergence, Law of Large Number (Strong Law and Weak Law), Central Limit Theorem, Inversion Theorem, Edgeworth Series, Gram Charlie's Series, Standard Errors of Estimators in Large Samples (Mean, Variance, Standard Deviation, Correlation Coefficient, Regression Coefficient, Coefficient of Variation).

References:

1. Evans, M., N. Hasting and B. Peacock (2000): *Statistical Distributions*, 3rd ed., Wiley, New York.
2. Hoel. P.G. (1971): *Introduction to Mathematical Statistics*, 4th ed., Wiley, N.Y.
3. Hogg, R. V. and A. T. Craig (2002): *Introduction to Mathematical Statistics*, 5th ed., Pearson, Education, Asia.
4. Johnson, N. and Balakrishrnan (1994): *Continuous Univarite Distribution*, 2nd ed. John Wiley and Sons.
5. Johnson, N., S. Kotz and A. W. Kemp (1994): *Univariate Discrete Distribution*, 2nd ed. John Wiley and Sons.
6. Kendall & Stuart (1952): *Advanced Theory of Statistics*, Vol.1, 4th ed., Charles Griffin, London
7. Kotz, S., N. Balakrishnan and N. L. Johnson (2000): *Continuous Multivariate Distributions,* **Vol. 1***, Models and Applications*, 2nd ed., Wiley, New York.
8. Lindley D.V. (1965): *Probability and Statistics*, Part I & II, CUP
9. Meyer, P. L. (1970): *Introductory Probability and Statistical Applications*, 2nd ed., Oxford and IBH
10. Mood, A. M., F. A. Graybill and D. C. Boes (1974): *Introduction to the Theory of Statistics*, 3rd ed. Tata McGraw-Hill.
11. Wonnacott,T.H & Wonnacott, R.J. (1977) : *Introductory statistics*,3rd Ed., Wiley
12. Yule, G. (1969): *An Introduction to the Theory of Statistics*, 14th ed., Charles Griffin, London.
13. Ashraf Ali: Theory of Statistics, vol-II

STAT 2202
Real Analysis
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Sets: Function, relation, equivalence relation, Real valued function, Open set, Dense Set, Countability, compact and connected sets, Monotonic class of sets, Additive class of sets.

Sequences and Series: Introduction, Convergence principle, Convergence and absolute convergence of series, Comparison test, ratio test, Root test, Integral test, Rearrangement of absolute convergent series, Cauchy's convergence, Multiplication of absolutely convergent series, Abel's Lemma, Dirichlet's test, Abel's test for conditional convergent power series.

Real Functions: Continuity, Properties of continuous functions, Uniform continuity, The Exponential, Logarithmic and Trigonometric functions, Derivatives, Rolle's theorem, Mean value theorems, Cauchy's mean value theorem, Taylor's theorem with Lagrange's and Cauchy's form of the remainder.

Riemann Integral: The existence of the Riemann integral of a continuous function, Simple properties. First and second mean value theorem, Convergence and absolutely convergence of improper and infinite integrals, Sequences and series of functions, Uniform convergence, comparison test, Term by term integration and differentiation.

Differentiation: Partial differentiation, Jacobians and its properties, Taylor's theorem for several variables, Principles of maxima and minima for several variables, Lagrange's multipliers, Local maxima and minima.

Multiple Integral: Double integral, Triple integral, Line and surface integral.

References:

1. Apostel, Tom M. (1992): *Mathematical Analysis*, McGraw Hill N.Y.
2. Binmore,G.H. (1965): *Foundation of Analysis*, Books I & II, CUP, London

3. Burkill, J.C. (1962): *A First Course in Mathematical Analysis*, CUP, London
4. Courant, H.(1988): *Differential and Integral Calculus*, Vol. II & III, Blackie and Sons, N.Y.
5. Goldberger, S.: *Method of Real Analysis*, McGraw Hill, N.Y.
6. Gupta, S. L., Nissha Rani (1993): *Fundamental Real Analysis*, 3rd rev. ed. Vikas
7. Hardy, G.H. (1983): *A First Course in Pure Mathematics*. CUP, London
8. Hobson E. *The Theory of functions of a Real Variable and Theory of Fourier Series*
9. Khanna M L, *Real Analysis*
10. Lipshutz (1981): *Set Theory*, McGraw Hill, N.Y.
11. Parzynoski & Zipse (1987): *Introduction to Mathematical Analysis*, McGraw Hill, N.Y.
12. Rudin, W (1976): *Real Analysis*, Academic Press, N.Y.

STAT 2203
Analysis of Variance and Design of Experiments
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Elimination of systematic variation, Assumptions underlying Analysis of variance, Models of ANOVA - Fixed Effect, Mixed Effect and Random Effect Models, Analysis of variance corresponding to One- Way, Two-Way and Three-Way classifications, Multiple Mean Comparisons. Basic Principles of Design of Experiments, Analysis of orthogonal design: Completely Randomized Design, Randomized Block Design, Analysis including interaction effects. Latin square Design. Multiple Comparison, Missing plot technique, Factorial Experiments 2p, 3p Confounding in factorial Experiments, Total and Partial confounding, Non-orthogonal Designs, Ideas of Incomplete Block Design, Covariance Analysis with one concomitant variable, Variance Components Analysis.

***References**:*

1. Cochran & Cox (2000): *Experimental Designs*, 2nd Ed., Wiley, N.Y.
2. Cox, D.R (1958): *Planning of experiments*, Wiley, N.Y.
3. Das, M. N. and N. C. Giri (1986): *Design and Analysis of Experiments*, 2nd Ed., Wiley Eastern Ltd., India.
4. Fisher, R.A. (1995): *The Design of Experiments*, 8th ed., Hafner Publishing Co. N.Y.
5. Hitson, A. (1995): *The Analysis of Variance*
6. John & Quenouille (1977): *Experiments Design and Analysis*, 2nd Ed., Charles Griffin, London
7. John, P W M: Statistical *Design and Analysis of Experimental Designs*, Collier-Macmillan, N.Y.
8. Kempthorne, O. (1952): The *Design and Analysis of Experiments*, 2nd ed., Wiley, NY.
9. Montgomery D. C (2003): *Design and Analysis of Experiments*, 5th ed., Wiley, N.Y. (Principal Text)
10. Rao C. R.& J. Kieffer (1988): *Estimation of Variance Components*, North Holand, N.Y.
11. Scheffe, H. (1959): *Analysis of Variance,* Wiley, NY.
12. Snedecor,G.W (1967): *Statistical Methods*, 10th Ed., Prentice Hall of India
13. Steel, R. G. D. and J. H. Torrie (1980): *Principles and Procedures of Statistics*, 2nd ed.
14. Walter, T. Federrer (1967): *Experimental Design: Theory and Application*
15. Yates, F. (1937): *Design and Analysis of Factorial Experiments*, Harpenden, Herts, England

STAT 2204
Computer Programming
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

C Programming: Introduction, importance of C, sample C programs, basic structure of C programs, programming style, executive of C program.

Sequential structure -Overview, character set, data types, classes of data, arithmetic operations, expressions, assignment statements, input and output.

Selective structure - overview, relational operators, logical operators, conditional statements, repetitive structure, functions, arrays, pointers. Application of programming in C for statistical computation.

Statistical Software Package: Overview of statistical software packages: SPSS, STATA, Statistica, Minitab, R **,**SAS, S-plus, Maple, E-views. Application and comparison.

SPSS : Overview, introducing SPSS for windows, defining variable and value labels, entering data from a questionnaire, computing and recording variables, graphs, descriptive statistics, cross tabulation, comparing means, regression and correlation, multivariate analysis.

Maple: Introduction to the Maple language, arithmetic expressions, statements and assignments, data types, array, table, built in maple functions and operations with functions, differentiation and its uses, maximum-minimum problems, differential equations in maple, integration and its uses, multiple integration, basic operation of matrices, solution of simultaneous equations, sequences, sequences and series, creating mathematical functions, inverse functions, Taylor's theorem.

References:

1. Balagurusamy,E.(2007): *Programming in ANSI C,* Tata McGraw-Hill, New Delhi.
2. Byron S. Gottfried (2006): *Programming with C*, Schaum's Outline Series, 2nd Edition, Tata McGraw-Hill.
3 Cody, R. P. and Smith, J. K. (1991): *Applied Statistics and the SAS Programming Language*, 3rd edition, Prientice Hall, Inc., New Jersey.
4 John Maindonald and John Braun (2003). *Data Analysis and Graphics Using R*. Cambridge University Press.
5 Norusis, M. J. (1988): *A Guide SPSS/PC for Data Analysis*, SPSS Inc., USA.
6 Peter Dalgaard (2008): *Introductory Statistics with R*, Springer.
7 Richard M. Heiberger and Burt Holland (2004): Statistical Analysis and Data Display*: An Intermediate Course with Examples in S-Plus, R, and SAS,* Springer.

STAT 2205
Environmental Statistics
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

UnderSTATnding Environmental Pollution: Pollution and Its Importance, Why does Pollution Happen? Pollutant Sources, Detail Study of Air and Water Pollution, Global Climate Change.

Stochastic Process in Environment: Applications of Bernoulli, Poisson and Normal Processes to Environmental Problems.

Environmental Sampling: Network Sampling, Composite Sampling, Ranked-Set Sampling.

Detectability of Sampling: Basic Concept of Detectability, Constant Detectability over Region, Estimating Detectability, Effect of Estimated Detectability, Detectability with Simple Random Sampling.

Diffusion and Dispersion of Pollutants: Wedge Machine, Particle Frame Machine, Plume Model.

Dilution of Pollutants: Deterministic Dilution, Stochastic Dilution, Theory of Successive Random Dilution (SRD), application of SRD to Environmental Phenomena: Air Quality, Indoor Air Quality, Water Quality, Concentrations of Pollutants in Soils, Plants and Animals, Concentration in Food and Human Tissue.

Statistical Theory of Rollback: Predicting Concentrations after Source Control, Correlation, Previous Rollback Concepts, Environmental Transport Models in Air and Water.

References:

1. Barnett, V. and Turkman, K. F. (1993): *Statistics for the Environment,* John Wiley and Sons, Chichester.
2. Barnett, V. (2004): *Environmental Statistics: Methods and Apllications*, John Wiley and Sons, New York.
3. Hill, M. K. (2004): *Understanding Environmental Pollutions*, Combridge University Press, London.
4. Thomson, S. (1992): *Sampling,* John Wiley and Sons Inc., New York.
5. Wayne, R. Ott. (2000): *Environmental Statistics and Data Analysis,* Lewis Publishers, England.

STAT 2206
Statistical Data Analysis-X (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Analysis of variance of one way, two way and three way classified data, Analysis of variance of CRD, RBD and LSD, Estimates of one missing value in RBD and LSD and ANOVA of these designs, Analysis of factorial experiments and total and partial confounding, Covariance analysis of one way and two way classified data with one concomitant variable.

STAT 2207
Statistical Data Analysis-XI (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Construction of frequency table based on ungrouped data and computation of various measures of central tendency: AM, GM, HM. Dispersion: Range, standard deviation, mean deviation from mean, moments, Skewness and kurtosis,2. OLS estimation of the regression model parameters, Fitting polynomial regression model, orthogonal polynomial, Small sample test of significance based on χ^2, t and F distributions, Test for independence and association in contingency table, Matrix operation: transpose, addition, subtraction, multiplication and inversion, Solution of linear algebraic equations by applying existing functions, Plotting of p. d. f. of different probability density functions.

STAT 3101
Statistical Estimation
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Point Estimation: Problem of Point Estimation, Properties of Estimator, Mean Squared Error, Unbiasedness, Consistency, Loss and Risk Function, Sufficiency, Fisher's Consistency, Methods of Estimation:-Maximum Likelihood Estimation, Method of Moments, Method of Minimum χ^2, Method of Least Squares, Method of Minimum Variance, Bayes' method. Minimax estimators, Correction for Bias, Minimum Variance Bound, Minimum Variance Unbiased Estimators, Uniformly Minimum Variance Unbiased Estimators, Consistent Asymptotically Normal Estimators, Best Asymptotically Normal Estimators, Cramer-Rao Lower Bound, Efficiency of Regular Estimators.

Sufficiency: Completeness, Rao-Blackwell Theorem, Lehman-Scheffe Theorem, Ancillary Statistics, Minimal Sufficient Statistics, Sufficiency of General Order Statistics.

Interval Estimation: Concept of central and non-central confidence interval, Confidence intervals for parameters of binomial, Poisson and normal distribution, large sample confidence interval, Bayesian interval, Neyman classical confidence intervals, finding confidence intervals by pivotal quantity method and statistical method.

Robust Estimation: Robust estimation of the Location and Scale parameters of symmetric distribution, Trimmed means, Linear combination of selected order statistics, M-estimates.

References:

1. Ali, M. A. (1993): *Theory of Statistics*, Vol. II.
2. Allen, S. and J. Keith (1986): *Advanced Theory and Mathematical Statistics*, Vol. II, Charles Griffun and Company Ltd.
3. Bickel, P.J. and K.A. Doksum (1977): *Mathematical Statistics*, Holden-Day Inc.
4. Brunk S.D. (1978) :*An Introduction to Mathematical Statistics*, 3rd ed., Collier Macmillan, Ny
5. Hajek, A. (1967): *Non Parametric Statistics*, Academic Press, N.Y.
6. Hogg, R. V. and A.T. Craig (2002): *Introduction to Mathematical Statistics*, 5th ed., Pearson Education (Singapore) Pvt. Ltd.

7. Hogg, R. V. and A.T. Craig (2002): *Introduction to Mathematical Statistics*, 5th ed., Pearson Education (Singapore) Pvt. Ltd.
8. Kendall, M.G.& A. Stuart (1963): *The Advanced Theory of Statistics* Vol II. 5th ed., Charles Griffin and Co. London
9. Lehmann, E.L. and G. Cassela (1998): *Theory of Point estimation*, Springer Verlag, N. Y.
10. Lindley, D.V (1965): *Introduction to Probability and Statistics*, Part-II.C.U.P.London
11. Mood, A.M., F. A. Graybill and D.C. Boes (1994): *Introduction to the theory of Statistics.* 5th ed., McGraw-Hill, New York.
12. Rao, C.R. (1984): *Linear Statistical Inference and its Applications*. 2nd ed.,Wiley Eastern; New Delhi.
13. Rohatgi, V. K. (1993): *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern.
14. Siegel, S.& Castellan, N.J (1988): *Non Parametric Statistics.* 2nd ed. Castell, N.J. McGraw-Hill.
15. Huber, P.J. (1981). *Robust Statistics*, Wiley, New York.
16. Rousseeuw & Leroy (1987): *Robust Regression and Outlier Detection,* Wiley,

STAT 3102
Stochastic Processes
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Generating Functions: Characteristic function, Probability generating function (p.g.f), Convolution, Inversion Theorem.

Limit Theorems: Mutual independence of random variables, Convergence of sequence of random variables, Laws of large numbers, Central limit theorem.

Stochastic Processes: Definition**,** Classifications, Renewal equation, Delayed recurrent events, Number of occurrences of a recurrent event. Application to the theory of success runs.

Random Walk and Ruin Problem: The classical ruin problem, Expected duration of the game. Generating functions for the duration of the game and for the first- passage times.

Markov Chains: Transition matrix. Higher transition probabilities, Classification of states and chains, Ergodic properties, Evaluation of Pn .

Finite Markov Chains: General Theory of random walk with reflecting barriers, transient states, Absorption probabilities, Application to recurrence times.

Homogeneous Markov processes: Poisson process, Simple birth process, Simple death process, Simple birth-death process, Effect of immigration, Queuing process, Single server queues, Equilibrium theory, Queues with many servers, Limiting properties of queues.

Point process: Stationary point process, Renewal process, doubly stochastic process.

Branching process: Structure of the process, Branching process, Age dependent branching process, Branching renewal process.

Reference:

1. Bailey, N.T.J. (1964): *The Elements of Stochastic Processes*, Wiley, N.Y.
2. Bartlett, M.S. (1955): *An Introduction to Stochastic Processes*. 5th Ed.CUP, London

3. Bhat, U.N. (1981): *Elements of Applied Stochastic Processes*, 2nd Ed. Wiley N.Y.
4. Billingsley, P. (1991): *Probability and Measure*, 2nd ed., Wiley, New York.
5. Cox and Miller (1985): *The Theory of Stochastic Process* 2nd ed., Chapman & Hall, London.
6. Feller, W. (1988): *An introduction to the Probability and its Application*. Vols. I & II. 3rd Ed. Willey & Sons Ltd. N.Y.
7. Grimmett, G.R. & D.R. Stirzaker (1992): *Probability and Random Processes*, Clarendon Press; Oxford University Press, London.
8. Karlin. S (1975): *A First Course in Stochastic Processes*, 2nd ed., Academic Press, N.Y.
9. Mehedi, J. I1994): *Stochastic Process*, 2nd ed., Wiley Eastern.
10. Prabhu (1980): *Stochastic Process*, Springer Varleg.
11. Ross, S.M. (2003): *Introduction to Probability Models*, 8th ed. Academic Press.
12. Srinivasan, S. K. and K. M. Nahata (1976): *Stochastic Process*, Chapman and Hall.

STAT 3103
Multinormal and Order Statistics
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Distribution of Quadratic Form: Review of sampling distribution, non-central Chi-square, non-central F and non-central t distribution, their Properties and Application, Decomposition of sum of squares of normal variables, Distribution of general quadratic forms, Expected values, Moments and moment generating functions.

Multinormal Distribution: Marginal distribution Conditional distribution. Moments and moment generating function, Properties of multi-normal distribution, Distribution of the simple correlation coefficient in the non-null case, Distribution of Pearson's Chi-square criteria.

Order Statistics: Definition, Joint Distribution of n Order Statistics, Marginal Distribution of Order Statistics, Conditional Distributions of Order Statistics, Distribution of Median and Range, Order Statistics for Discrete and Continuous Parent Distributions, Exact Moments of Order Statistics, Large-Sample Approximations to Mean and Variance of r th Order Statistics, Asymptotic Distribution of Order Statistics, Application (regular and irregular).

References:

1. Arnold, B.C., Balakrishnan, N. and Nagaraja, H.N. (1992): *First Course in Order Statistics*, John Wiley, New York.
2. Balakrishnan, N. and A. C. Cohen (1991): *Order Statistics and Inference*: Estimation Methods, Academic Boston: Academy Press.
3. David, H.A. (1980): *Order Statistics*, 2nd ed. Wiley, N.Y.
4. Gibbons, J.D. and Chakraborti, Subhabrata (1992): *Non parametric Statistical Inferences,* Marcell Dekkar.
5. Graybill, F. (1982): *An Introduction to Linear Statistical Models*, Vol. I. 2nd Ed. McGraw-Hill, N.Y.
6. Hogg, R. V. and A. T. Craig (2002): *Introduction to Mathematical Statistics*, 5th ed., Pearson Education (Singapore) Pvt. Ltd.
7. Sprent, P. and M. Smeeton (2000): *Applied Non parametric Statistical Methods,* Chapman and Hall/CRC.

STAT 3104
Survey Methods
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Sample Survey: Ideas of field survey, Sample survey and complete enumeration, Steps in a sample survey, Desiderata in planning a sample survey, Preparation of questionnaire, Schedules, Instruction etc, Survey, enumeration, Pilot survey, Requirement of a good sample design.

Sampling Preliminaries: Probability and non-probability sampling, Sampling with and without replacement with equal and unequal probabilities, Sampling and non-sampling errors, Bias, Accuracy and Precision.

Random Sampling: Procedure of selecting a random sample, Sampling for variables and Attributes, Study of Simple random sampling, Stratified random sampling, Systematic sampling, Cluster sampling, Ratio and Regression methods of estimation, Comparison of sampling procedures, Estimation for population total, mean variance and proportion.

Non-Random Sampling: Purpose/ Judgment sampling, Quota sampling, Convenience sampling, Merits, Demerits and application.

References:

1. Barnett ,V. (1979): *Sample Surveys*: Principles and Methods, Edward Arnold, London.
2. Cassel, C.M, Sardnal, M (1977): *Foundation of Inference in Survey,* Wiley.
3. Wretman, J.H. (1992): *Sampling,* Springer-Verlag, New York.
4. Chudhuri, A. and H. Stenger (1992): *Survey Sampling Theory and Methods.*
5. Cochran, W.G. (2002): *Sampling Techniques,*4th ed. Wiley, N.Y.
6. Des Raj.(1968): *Design of Surveys,* Tata McGraw- Hill, N.Y.
7. Hensen, Harwitz, Madaw (1953): *Sample Survey Methods and Theory,* Wiley Eastern.
8. Jessen, R. J. (1978): *Manual Sampling Techniques.*
9. Johnson, N.L & Smith, H. (1969): *New Developments in Survey - Sampling,* Wiley Inter Science.
10. Kish, L. (1995): *Survey Sampling,* Wiley, N.Y.
11. Mukhopadhayay (2000): *Theory and Methods of Survey Sampling,* Prentice-Hall of India (P.) Limited, New Delhi.
12. Murthy, M. N. (1977): *Sampling Methods.* 2nd ed.
13. Samdal, C.E., Swenson, B. and Wretman (1992): *Modeling Assisted Survey Sampling.*
14. Som, R.K. (1973): *Practical Sampling Technique,* Marcell Dekkar.
15. Sukhatme, P.V., V.V. Sukhatme, S. Sukhatme and C. Ashok (1954): *Sampling Theory of Surveys with Application,* 2nd ed., IOWA State University Press, U.S.A.

STAT 3105
Operation Research
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Overview: Definition, Characteristics, Scope and Limitations of Operational Research, Problem Formulation and Modeling in Operational Research, Classification of Operational Research, Important Characteristics of Operational Research Techniques.

Linear Programming: Concept and Basic elements of Linear Programming (LP). Formulation of Linear Programming (LP) Problem, Hyper-Plane, Hyper-Sphere, Open Set, Closed Set, Convex Set, Convex Polyhedron, Convex and Concave Functions, Basic Solution, Basic Feasible Solution, Non-Degenerate and Degenerate Basic Solution, Theorem Related to Solution, Properties of Solution to Linear Programming Problem, Graphical Solution, Generating Extreme Point Solutions, Simplex Methods: Theory and Applications, Revised Simplex Method, Duality Problems of Linear Programming, Introduction to Transportation Problem, Setting up of Transporting Problem with Its Solutions.

Game Theory: Introduction, Pure and Mixed Strategy Games, Two Person Zero Sum and Non-Zero Sum Games, Solution of Game by Graphical Methods, Simplex Method, Approximate Solution of Game by Brown's Algorithm.

Inventory Problem, Non-linear Programming and Its Applications.

Stochastic Programming, Decision Theory.

References:

1. Gass, S. I. (1975): *Linear Programming Methods and Applications,* 4th edition, McGraw-Hill Ltd., New York.
2. Gupta, D. K. and Man Mohan (2001): *Linear Programming and Theory of Games,* 8th edition, Sultan Chand & Sons, New Delhi.
3. Hadley, G. (1990): *Linear Programming*, Oxford and IBH, Narosa, New Delhi.
4. Karak, P. M. (1991): *Linear Programming and Theory of Games*, Chhaya Prakashani, India.
5. Saaty, T. L. (1959): *Mathematical Methods of Operations Research*, McGraw-Hill, New York.
6. Sasieni, M. and Yaspan, A. (1959): *Operations Research- Methods and Problems*, Wiley, New York.
7. Swarup, K., Gupta, P. K. and Mohan, M. (2003): *Operations Research*, 11th edition, Sultan Chand and Sons, New Delhi.
8. Taha, H. A. (2003): *Operations Research: An Introduction*, 7th edition, Prentice-Hall: New Delhi.
9. Mokhtar S. Bazaraa, John J. Jarvis, Hanif D. Sherali (2010): *Linear Programming and Network flows*, 4rth edition, John Wiley & Sons.
10. Hillier and Leiberman (2001): Introduction to Operations Research, 7nth edition.

STAT 3106
Statistical Data Analysis-XII (Lab)
Full Marks-50
No. of Lectures: Minimum-15.
Duration of each lecture: 1.5 hours
Duration of Examination: 2 Hours.

Drawing Random Samples from Different Distributions. ML method, Bayes method, Method of least squares, Method of Moments, Confidence Estimation: Mean, Difference of Means, Proportions, Large sample confidence interval, Bayesian interval, Robust estimation.

STAT 3107
Statistical Data Analysis-XIII (Lab)
Full Marks-50
No. of Lectures: Minimum-15.
Duration of each lecture: 1.5 hours
Duration of Examination: 2 Hours.

Markov-Chain, Closed Sets, Classification of States, Properties of States, Chapman-Kolmogorov Equations, First Entrance Decomposition Formula. Ergodic Properties of Irreducible Chains, Higher Order and Secondary Probability, Recurrent Events, Delayed Recurrent Events, Periodic Chains, Transient and Recurrent States, Gambler's Ruin Problem, Estimating Transition Probabilities of Markov Chain, Asymptotic Behavior of $P_1 p$, Determination of Different Properties of Transition Probability Matrix, Homogeneous and Non-Homogeneous Poisson Process, Determination of Steady State Probabilities for Different Queuing Systems.

STAT 3108
Statistical Data Analysis-XIV (Lab)
Full Marks-50
No. of Lectures: Minimum-15.
Duration of each lecture: 1.5 hours
Duration of Examination: 2 Hours.

Drawing of random sample from finite population, Estimation of population Mean and standard errors under Simple random sampling, Stratified random sampling, Systematic sampling and Cluster sampling, Estimation of Parameters in Each Case, Estimation of Variance of Estimates of Parameters, Determination of Precision of Estimates, Relative Efficiency of Different Sampling Schemes, Determination of the optimum size of the sample and optimum cost.

STAT 3201
Hypothesis Testing
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Parametric Tests: Basic concepts, Idea of Null and Alternative Hypotheses, Simple hypothesis, Composite hypothesis, Critical region, Best critical region, Neyman-Pearson fundamental lemma, Most powerful test, uniformly most powerful test, Two-sided BCR.

Test of Significance: Test of single proportion, mean, variance, Correlation Coefficient and Regression Coefficients, Testing Equality of two and more proportions means and variances, Test for correlation and regression coefficients, Test for independence and association of attributes in r x c contingency tables, Exact test in 2 x 2 contingency table, Test for association in three - way contingency tables, Small sample tests of significance, Large sample tests.

.

Likelihood Based Test: Introduction, Distribution Likelihood Ratio (LR) Statistic, Asymptotic distribution of LR statistic. LR test in linear model, Lagrange Multiplier Test, Wald Test, Test consistency and Test efficiency.

Sequential Test: Introduction. Sequential Probability Ratio (SPR) Test. OC and ASN function.

Introductory Bayesian Hypothesis Testing: Test of hypothesis concerning normal distribution in predictive approach, Bayesian treatment of linear model, Bayesian approach to contingency tables.

References:

1. Congdon, P. (2001): *Bayesian Statistical Modeling*, Wiley.
2. Cox, D.R. & D.V. Hinkly (1977): *Theoretical Statistics*, C & H, London.
3. Cassela, G. and R. Berger (2001): *Statistical Inference*, Wadsworth Publishing Co.
4. Hogg, R. V. and A. T. Craig (2002): *Introduction to Mathematical Statistics*,5th ed., Pearson Education (Singapore) Pvt. Ltd.
5. Kalbfleisch, J. (1981): *Probability and Statistical Inference*, Vol.2, Springer-Verlag.
6. Kendall, M.G. and A. Stuart (1963) *The Advanced Theory of Statistics*, Vol.II, Charles Griffin and Company Ltd.
7. Lehmann, E. L.(2000): *Testing of Statistical Hypothesis* 4th ed. Wiley, N.Y.
8. Silvey, S. D. *Statistical Inference*, C & H, London.
9. Mukhopadhaya, N. (2000): *Probability and Statistical Inference*, Marcel Dekkar.
10. Rao, C. R. (1984*): Linear Statistical Inference and its Applications*.2nd ed. Wiley, N.Y.
11. Wald, A (1947): *Sequential Analysis*, Wiley, N.Y.
12. Wald, A. (1950): *Decision Theory*
13. Wetherill, G.B. (1975): *Sequential Methods in Statistics*, 3rd. Ed.& Glazebrook C & H, London
14. Zacks, S. (1971): *Theory of Statistical Inference*, Wiley, N.Y.

STAT 3202
Time Series Analysis
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Overview: Meaning of Time Series, Objectives of Time Series Analysis, Simple Time Series Models, Stationary Models, Autocorrelation Function, Estimation and Elimination of Trend and Seasonal Components, Testing, Estimated Noise Sequence Problems.

Stationary Processes: Basic Properties, Linear Processes, ARMA Processes, Properties of Sample Mean and Autocorrelation Function, Forecasting Stationary Time Series, World Decomposition Problems.

ARMA Models: ARMA (p, q) Process, ACF and PACF of ARMA (p, q) Process, Forecasting ARMA Process Problems. Concept of Autoregressive Conditional Heteroscedasticity (ARCH) Model, Generalized ARCH (GARCH) Model.

Spectral Analysis: Spectral Densities, Periodogram, Time-Invariant Linear Filters, Spectral Density of ARMA Process Problems.

Modeling and Forecasting with ARMA Process: Preliminary Estimation, Maximum Likelihood Estimation, Diagnostic Checking, Forecasting, Order Selection, Problems.

Nonstationary and Seasonal Time Series Models: ARIMA Models for Nonstationary Time Series, Indentification Techniques, Unit Roots in Time Series Models, Forecasting ARIMA Models, Seasonal ARIMA Models, Regression with ARMA Errors, Problems.

Forecasting Technique: ARAR Algorithm , Holt-Winters Algorithm, Holt-Winters Seasonal Algorithm, Choosing Forecasting Algorithm, Problems.

Multivariate Time Series: Second-Order Properties, Mean and Covariance Function, Multivariate ARMA (MARMA) Models, Best Linear Predictors, Modeling and Forecasting with MAR or VAR Process. VAR Models, Unit Root Models, Error-Correction Model, Co integration Analysis.

State-Space Models: State-Space Representation, Basic Structural Model, State-Space Representation of ARIMA Models, Kalman Recursions, Estimation for State-Space Models, State-Space Models with Missing Observations, EM Algorithm, Generalized State-Space Models.

References:

1. Brockwell, P. J. and Davis, R. A. (2002): *Introduction to Time Series and Forecasting*, Springer, New York.
2. Diebold, F. X. (2004): *Elements of Forecasting*, 3rd edition, Rahul Print O Pack, India.
3. Hamilton, J. D. (1994): *Time Series Analysis*, Princeton University Press, New Jersey.
4. Harris, R. and Robert, S. (2003): *Applied Time Series: Modeling and Forecasting*, Replika Press Pvt. Ltd., India.
5. Makridakis, S., Whellwright, S. C. and Hyndman, R. J. (1998): *Forecasting Methods and Applications,* 3rd edition, John Wiley and Sons, New York
6. Mukhopadhyaya, P. (1999): *Applied Statistics*, Books and Allied (P) Ltd.

STAT 3203
Econometrics
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Basic Concept: Meaning, Methodology of Econometrics, Types of Econometrics, Nature and Source of Data for Econometric Analysis, Role of Computer in Econometric Analysis.

Review of Multiple Linear Regression, Examination of Residuals to Detect Assumption Violations, Likelihood Ratio, Wald, Lagrange Multiplier and Other Suitable Tests for Testing Regression Parameters, Verification of BLUE Properties of Linear Regression by Monte Carlo Experiments.

Multicollinearity: Nature of Multicollinearity, Theoretical Multicollinearity, Estimation in Presence of Multicollinearity, Theoretical and Practical Consequences of Multicollinearity, Detection of Multicollinearity, Remedy and Measures of Multicollinearity.

Heteroscedasticity: Meaning and Nature of Heteroscedasticity, Ordinary Least Squares and Generalized Least Squares, Estimation in Presence of Heteroscedasticity, Consequences of Using Ordinary Least Squares in Presence of Heteroscedasticity, Detection of Heteroscedasticity by Informal and Formal Methods, Park, Glejser, Spearman's Rank Correlation, Goldfield-Quandt, and Breusch-Pagan-Godfrey Heteroscedasticity Tests, Remedial Measures of Heteroscedasticity by Weighted Least Squares.

Autocorrelation (Serial Correlation): Meaning and Nature, Ordinary Least Squares Estimators and Best Linear Unbiased Estimators, Estimators in Presence of Autocorrelation, Consequences of Using Ordinary Least Squares in Presence of Autocorrelation, Detection of Autocorrelation by Graphical Methods, Run Test, Durbin-Watson D-Test, H-Test, Asymptotic Autocorrelation, Remedial Measures of Autocorrelation for Both Known and Unknown ρ, Cochrane - Orcutt Iterative, Durbin's Two Step and EGLS Methods of Estimating ρ,

Monte-Carlo Experiment: Consequence of Autocorrelation.

Model Selection: Leamer's and Hendry's Approach to Model Selection, Non-Nested Hypothesis Test by (i) Discrimination Approach (ii) Discerning Approach and (iii) other Criteria Such as Hocking's S_p Measures, Mallow's C_p Measure, Amemiya's PC Measure and Akaike's AIC Measure, Schwarz Criterion, Hannan Quinn and Shibata Criterion.

Dummy Variables: Meaning, Nature of Dummy Variable, Regression on Different Combination of Quantitative and Qualitative Variables, Testing Structural Stability of Regression Model, Comparing Two Regression by Dummy Variables, Comparison with Chow Test, Use of Dummy Variables in Seasonal and Piece-wise Linear Regression and Combing Time and Cross Sectional Data, Dummy Variable Trap, Method of Avoiding Dummy Variable Trap.

Detail Study of Linear Probability, Logistic, Probit and Tobit Models to Study Regression on Dummy Dependent Variables.

Dynamic Econometric Model: Autoregression, Distributed Lagged Variables, Lag Model, Meaning of Dynamic Distribution Lag and Autoregressive Models, Role and Reasons for Lags in Econometric Model.

Method of Estimation of Lag by Adhocmollud, Koyck and Almon Method of Estimating Distributed Lag Model, Median Lag of Different Models, Use of Method of Instrumental Variable, Detecting Autocorrelation in Autoregressive Model by Durbin H-Test, Granger Causality Test.

References:

1. Gujarati, D. (2003): *Basic Econometrics*, 4th edition, McGraw-Hill, New York.
2. Judge, G. G. Hill, R. C., Griffiths, W. E., Lütkepohl, H. and Lee, T. C. (1988): *Introduction to the Theory and Practice of Econometrics*, 2nd edition, John Wiley and Sons, New York.
3. Greene, W. H. (2003): *Econometric Analysis*, 5th edition, Pearson Education, India.
4. Johnston, J. (1977): *Econometric Methods,* 4th edition, McGraw –Hill, New York.
5. Johnston, J. and Dinardo, J. (1997): *Econometric Methods*, 4th edition, McGraw-Hill, New York.
6. Koutsoyiannis, A. (1977): *Theory of Econometrics,* 2nd edition, Palgrave Macmillan Ltd., India.

STAT 3204
Statistical Simulation and Data Processing
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 3 hours
Duration of Examination: 2 hours

Introduction to Simulation: Basic concepts of systems, models, and simulation, Discrete and continuous systems simulation, Purposes of simulation, Advantages and disadvantages of simulation, Steps in a simulation study, Simulation application examples - queuing system, inventory system.

Random-Number and Random Variate Generation: Concept of random numbers, Techniques for generating random numbers, Tests for random numbers, Methods for generating random variates–inverse transformation, composition, convolution, acceptance-rejection, Comparison of the methods, Applications of probability distributions in simulation – Uniform, Exponential, Weibull, Gamma, Normal, Binomial, Poisson. Monte Carlo sampling, Latin hyper cube sampling.

Verification and Validation of Simulation Models: Model building, verifications, and Validations, Techniques for verification and validation of simulation models, Statistical methods for comparing real-word observations and simulation output data.

Analysis of Simulation Data: Identifying the distribution with data, Parameter estimation, Goodness-of-fit tests, Output analysis for terminating and steady-state simulations.

Simulation Languages and Packages: Concept of simulation software packages, Applications of statistical software.

SPSS

Overview: Meaning of SPSS, Concepts of Commands, Syntax Diagram, Running Commands in Inter-Relative and Batch Mode, Sub-Commands, Keywords, Values in Command Specifications, String Values in Command Specifications, Delimiters Command Order.

Different Types of Files (Command, Journal, Data, Raw Data, SPSS-Format Data, SPSS Portable, Working Data, Files from other Software Applications), Variable, Variable Formats, Transformation Expressions, Functions, Numeric Functions, Random Variable of Distribution Functions, Missing Values in Numerical Expression.

Arithmetic, Relational and Logical Operators, Order of Evaluation, Missing Values Functions, Input Data Specification, Commands and Program States, File Definition Commands, Utility Commands, Input Program Command, Transformation Commands, Restricted Transformations, Procedures, Generating Random Data, Commonly Used Commands for Statistical Analysis.

SPSS for Windows: Basic Steps in Analysis, Windows and Menus, Dialog, Basic Structure of SPSS Data File, Entering Numerical, Non-Numeric Data, Defining Data, Defined Value Labels to Enter Data, Reading Spreadsheet Data, Database, Text Data, Transforming Data Values, Constructing Tables, Statistical Analysis with Dialogue Interface, Running SPSS using Production Facility.

Input Statement: List Directed and Column Input, Pointers and Formats, Reading Structured and Unstructured Data Format List.

External File: Reading and Writing Raw and System Files, Reading and Writing Data from Program and ASCII Data from External File, File Options, Writing Data to External File, Creating and Reading Permanent SAS Data Set, Working with Large Data Sets Problems.

Importing and Exporting Data: Reading Data from Different Formatted Data Files, Converting Different Database Formatted Files to SAS System Files.

Arrays Used in SAS: Use of Array for Missing Values to Create New Variables, Transformation of Data Set, Temporary Arrays, Multidimensional Arrays.

Data Manipulation: Data Set Subsetting, Concatenating, Merging and Updating Subsetting, Combining Different Data from Multiple Files, Table Look Up, Updating Master File from Update File.

SAS Functions: Arithmetic and Mathematical, Random Number, Time Data, Input and Output, String and Lag Functions.

Use of SAS Program (Codes) and Functions for Descriptive Statistics, Correlation and Regression, Questionnaire Design and Analysis, Analysis of Variance, Multiple Regression.

R: Simulation by R.

References:

3 Afifi, A. A. and Azen, S. P. (1979): *Statistical Analysis: A Computer Oriented Approach*, 2nd edition, Academic Press, New York.
4 Averill. M. Law (1991): Simulation Modeling and Analysis, Second Edition, W. Kelton
5 Bartley, P., Fox, B. L. and Schrage, L. E. (1987): *A Guide to Simulation*, 2nd edition, Springer-Verlag, New York.
6 Cody, R. P. and Smith, J. K. (1991): *Applied Statistics and the SAS Programming Language*, 3rd edition, Prientice Hall, Inc., New Jersey.
7 David Vose (1996): Qualitative Risk Analysis: A Guide to Simulation Modeling, John Wiley & Sons.
8 Fred J. Maryanski (1980): Digital Computer Simulation, CBS Publishers, India
9 Geoffrey Gorden (1978): System Simulation, Prentice - Hall, Inc. N.J.
10 Jerry Banks, J. S. Carson, and B. L. Nelson (1999): Discrete-Event System Simulation, 3rd edition, Prentice-Hall.

11 Law, M. A. and Kellon, W. D. (2000): *Simulation Modeling and Analysis*, 3rd edition, Tata McGraw-Hill, New Delhi.
12 Narsingh Deo (1997): System Simulation with Digital Computer, Prentice -Hall of India, New Delhi.
13 Norusis, M. J. (1988): *A Guide SPSS/PC for Data Analysis*, SPSS Inc., USA.
14 Ross, B. M. (1997): Simulation, 2nd edition, Academic Press, USA.
15 Rubinstein, R. Y. (1981): *Simulation and the Monte Carlo Method,* John Wiley and Sons, New York.

STAT 3205
Statistical Data Analysis-XV (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Large sample test of significance, Small sample test of significance based on χ^2 , t and F distributions. Tests for several means and variances, Test for independence and association in contingency table, exact test in a 2 x 2 contingency table, Parametric test (To be assigned by course tutor) ,Likelihood ratio tests, SPRT, OC and ASN function, Bayesian hypothesis testing.

STAT 3206
Statistical Data Analysis-XVI (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Measurement of Secular Trend, Seasonal Variation, Cyclical Movement and Irregular Components, Spencer's 15 and 21-Points Formula, Correlogram Analysis, Diagnostic Checking, Forecasting, Spectral Analysis.

STAT 3207
Statistical Data Analysis –XVII (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Tests for Autocorrelation, Multicollinearity, Heteroscedasticity, Estimation of Parameters and Analysis of Data in Presence of Autocorrelation, Multicollinearity and Heteroscedasticity; Estimation of Parameters in Presence of Lagged Dependent Variable, Dummy Variable.

STAT 3208
Statistical Data Analysis -XVIII
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Simulation: Generating Random Number from Uniform, Binomial, Poisson, Normal, Exponential, and Gamma by Different Monte-Carlo Methods and Using Standard Software and Computer Program; Testing Uniform Random Numbers using chi-square Test, Kolmogorov-Smirnov Test and Graphical Methods, Assess Different Statistical Properties of Generated Data, Integration by Monte-Carlo Simulation.

Problem Solving Though SPSS, SAS and R: Solving Different Statistical Problems by SPSS, SAS & R (Measures of Central Tendency, Measures of Dispersion, Correlation and Regression), Graphical Presentation of Statistical Data by SPSS, Analysis of Data by SPSS, Writing and Running Syntax in SPSS and SAS to Solve Different Statistical Problems.

STAT 4101
Multivariate Distribution
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Aspects of multivariate Analysis: Meaning and Applications of Multivariate Analysis, Meaning and Interpretation of Euclidian and Statistical Distances, Spectral Decomposition, Cholesky Decomposition of Positive Definite Matrix, DeterMining Square Root of Matrices, Partition of Covariance Matrices, Generalized Variance.

The multivariate normal distribution: Meaning, Derivation and Properties of multivariate Normal Distribution, Contour, Maximum Likelihood Estimator of Mean Vector and Variance Covariance Matrix, Large Sample Behavior of Mean Vector and Variance Covariance Matrix. Evaluating Normality of Univariate Marginal Distributions, Bivariate and Multivariate Distributions by P-P and Q-Q Plot, Steps in Detecting Outliers and Cleaning Data, Transformation to Near Normality by Square Root, Logit, Fisher's and Box-Cox Transformation, Sampling Distribution of Sample Mean and Sample Covariance Matrix, Wishart Distribution, Demerits of Multivariate Normal Likelihood and Estimation of MV and CV by MLE Information of Sufficient Statistics for MNP.

Inferences about Mean Vector: Hoteling's T^2 Statistic, Derivation of Test, Defining Critical Region of Multivariate Normal Mean Vector, Relation with F Statistic and Wishart Random Matrix, LR Statistics, Derivation of the Distribution of LR Statistics to Test Mean Vector and DeterMining Confidence Region of Mean Vector. Multivariate Quality Control Charts: Charts for Individual Multivariate Observation, Ellipse Format Chart, T^2 Chart, Control Region for Future Individual Observation, Control Ellipse and T^2 Chart for Future Observation, Comparing Several Multivariate Means, Paired Comparison, Repeated Measures Designs for Comparing Treatments, One-Way ANOVA, MANOVA, Profile Analysis.

Multivariate Multiple Regression: Meaning, Functional Form and Underlying Assumptions, Likelihood Ratio Test for Regression Parameters, Predicting Multivariate Multiple Regression, Confidence Ellipse and Prediction Ellipse from Bivariate Responses.

References:

1. Johnson, R. A. and Wichern, D. W. (2002): *Applied Multivariate Statistical Analysis,* 5th edition, Pearson Education, Asia.
2. Anderson, T. W. (1984): *Introduction to Multivariate Analysis*, 2nd edition, John Wiley, New York.
3. Mardia, K. V., Kent, J. T. and Bibby, J. M. (1979): *Multivariate Analysis,* Academic Press, London.

STAT 4102
Sampling Techniques
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Sampling Strategy: Equal and unequal Probability Sampling with and without replacement. PPS and ΠPS Sampling procedures. Selection of Sample. The Horvitz-Thomson Estimator (HTE). Sampling schemes for use of HTE(:n=2 and general n). Other Schemes. Ordered and Unordered Estimators.

Sampling and Sub sampling of Cluster: Unequal size and varying probability cluster sampling. Relative Efficiency. Determination of optimum cluster size. Relative Accuracy's. Sub-sampling with units of Equal and Unequal sizes- Two stage, Three stage and Multistage sampling. Optimum sampling and sub-sampling fractions. Two stage and Three stage pps sampling.

Double Sampling Procedures and Repetitive Surveys: Introduction, Double sampling for Stratification, Ratio, Difference, Regression, Product and PPS estimation. Optimum allocation. Sampling on Two and/or More occasions. Repetitive surveys. Multi-phase sampling. Self-weighting sampling.

Non-Response: Introduction, Characteristics of Non-Response, Measuring Non-Response, Dealing with Non-Response, Perspectives on Non-Response, Estimation in Presence of Unit Non-Response, Methods of Reducing Non-Response and Response Errors.

References:

1. Raj, D. and Chandhok, P (1998): *Sample Survey Theory*, Narosa Publishing House, New Delhi.
2. Thompson, S. K. (2002): *Sampling*, John Wiley, New York.
3. Cochran, W. G. (1977): *Sampling Techniques*, 3rd edition, Wiley Eastern, New Delhi.
4. Hansen, M. H., Hurvitz, W. N. and Mado, W. G. (1953): *Sample Survey Methods and Theory*, Vol. I and Vol. II, Wiley, New York.
5. Jessen, R. J. (1978): *Statistical Survey Technique,*Wiley, New York.
6. Kish, L. (1995): *Survey Sampling*, Wiley, New York.
7. Levy, P. and Lemeshow, S. (1999): *Sampling of Populations: Methods and Applications*, Wiley, New York.
8. Mukhapadhyay, P. (1998): *Theory and Methods of Survey Sampling*, Prentice Hall, New Delhi.
9. Murthy, M. N. (1977): *Sampling Theory and Methods*, Statistical Publishing Society, Calcutta.
10. Sukhatme P. V. and Sukhatme B. V. (1984): *Sampling Theory of Surveys with Applications*, Indian Society of Agricultural Statistics, New Delhi.

STAT 4103
Actuarial Statistics
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Introduction: Definition of Actuarial Science, Its Relationship with Life Insurance, Important Uses of Actuarial Statistics Specially in Context of Bangladesh.

Compound Interest: Theory of Rates of Interest and Discount Including Theoretical Continuous Case of Forces of Interest and Discount, Annuities and Sinking Funds Including Continuous Case, Practical and Theoretical Applications Primarily to Mortgages and Bonds, Yield Rates.

Insurance and Pension: Economics of Insurance, Utility Theory, Application of Probability to Problems of Life and Death, Determination of Single Premium for Insurances and Annuities in both Discrete and Continuous Case, Theory and Practice of Pension Plan Funding, Assumptions, Basic Actuarial Functions, Population Theory Applied to Private Pensions, Survival Distributions, Life Tables, Life Insurance, Life Annuities, Net Premium, Premium Series, Multiple Life Functions, Multiple Decrement Models, Valuation Theory for Pension Plans, Expense Function and Dividends.

Exposure Formula: Assumed and Using Implications, Techniques of Calculating Exposures from Individual Records Including Consideration Involving Selection of Studies, Various Observation Periods and Various Methods of Tabulating Deaths, Techniques of Calculating Exposures from Valuation Schedules Including General Concepts of Fiscal Year, Use of Interim Schedules and Variations in Observations Period or Method of Grouping Deaths and Practical Aspects of Construction of Actuarial Tables.

References:

1. Ayres, F. Jr., (1963): *Mathematics of Finance,* Schaum's Publishing Co., New York.
2. Bathen, R. W. (1978): *Mortality Table Construction,* Prentcehall, New Jersey.
3. Bowers, N. L., Gerber, H. V., Hickman, J. C., Jones, D.A. and Nesbitt, C. J. (1978): *Actuarial Mathematics*, Society of Actuaries, Chicago.
4. Jordan, C. W. (1952): *Life Contingencies,* Society of Actuaries, Chicago.
5. Kellison, S. G. (1970): *Theory of Interest*, Richard D Irwin, London.
6. Parmenter, M. M. (1988): *Theory of Interest and Life Contingencies with Pension Application,* ACTEX Publication, Winsted, CT, USA.

STAT 4104
Categorical Data Analysis
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Overview: Categorical response data, response and explanatory distinction, measurement scale distinction, continuous and discrete distinction, qualitative and quantitative distinction.

Describing two-way contingency table: Contingency tables, independence, difference of proportions, relative risk, odds ratio, relationship between odds ratio and relative risk, odds ratio for $I \times J$ tables, summery

measures of association, measures of ordinal association, gamma, measures of nominal association, concentration and uncertainty measures.

Inference for two-way contingency tables: Poisson sampling, multinomial sampling, independent multinomial sampling, likelihood functions and maximum likelihood estimates, testing goodness of fit, testing a specified multinomial, testing Mendel's theories, theoretical justification, goodness of fit test with estimated expected frequencies, testing independence, Pearson Chi-squared test, likelihood ratio Chi-squared, invariance of Chi-squared to category orderings, partitioning Chi-squared, rules for partitioning, large sample confidence intervals, estimating odds ratios, estimating difference for proportions and relative risk, delta method, ASE gamma and other measures, exact tests for small samples, fisher's exact test, derivation of exact conditional distribution, other exact tests of independence, conditional versus unconditional tests, exact non-null inference, inference for the odds ratio.

Models for binary response variables: Generalized linear models, components of a generalized linear model, Logit models, log-linear models, logistic regression, linear probability model, logistic regression model, inference for logistic regression, inverse CDF links, Logit models for categorical data, Logit model for $I \times 2$ table, Logit models for higher dimensions, linear Logit model, goodness of fit as a likelihood ratio test, Probit and extreme value models, models with log-log link, fitting Logit models, likelihood equations, Newton-Rapson for logistic regression, conditional logistic regression, exact trend test.

Log-linear models: Log-linear model for two dimensions, independence model, saturated model, interpretation of parameters, models for cell probabilities, partial association, types of independence, log-linear models for three dimensions, hierarchical log-linear models, interpretation of model parameters, conditions for identical, marginal and partial associations, interpretation of three dimensional log-linear models, correspondence between log-linear and Logit models.

Fitting log-linear and Logit models: Likelihood equations for log-linear models, estimating expected frequencies by solving likelihood equations, direct versus iterative estimation, testing goodness of fit, corresponding Logit models, and estimating model parameters, difference between binary Logit and multinomial Logit model.

Building and applying log-linear models: Partitioning Chi-squared to compare models, strategies in model selection, sampling considerations, exploratory analysis, stepwise procedures, using causal hypothesis to guide model building.

References

1. Agresti, A. (1990): *Categorical Data Analysis*, John Wiley, New York.
2. Agresti, A. (1984): *Analysis of Ordinal Categorical Data,* John Wiley, New York.
3. Anderson, E. B. (1997): *Introduction to the Statistical Analysis of Categorical Data*, Springer-Verlag, New York.
4. Powers, D. A. and Xie, Yu. (2000): *Statistical Methods for Categorical Data Analysis,* Academic Press, London.

STAT 4105
Non-parametric tests
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Non-parametric Tests: Overview of Non-parametric Tests, Distinction with Parametric Tests, Concept of Distribution Free Test.

Test Based on Runs: Distribution Theory of Runs, Test Based on Total Number of Runs, Test Based on Length of Longest Run, Runs Up and Down, Randomness Test Based on Ranks.

Test of Goodness of Fit: Distribution Theory of Kolmogorov-Smirnov (K-S) One-Sample Test Statistic and Test based on K-S Test, Comparison of Chi-Square Test and Kolmogorov-Smirnov, Test for Goodness of Fit, Lilliefors' Test for Normality.

Rank-Order Statistics: Definition, Correlation between Variate Values and Ranks, Treatment of Ties in Rank Tests.

One-Sample and Paired-Sample Techniques: Sign Test, Wilcoxon Signed-Rank Test and Their Distributional Properties, Power and Confidence Interval Procedure, Binomial and Quantile Test.

General Two Sample Problem: Wald-Wolfowitz Runs Test, Kolmogorov-Smirnov Two-Sample Test, Median Test and Mann-Whitney U Test and Their Distribution Under Null Hypothesis, Confidence Interval Procedures.
Linear Rank Statistics: Definition, Distributional Properties of Linear Rank Statistics

Linear Rank Test for Location Problem: Wilcoxon Rank-Sum Test, Terry-Hoeffding Test, Van Der Waerden Test and Their Distributions Under Null Hypothesis.

Linear Rank Test for Scale Problem: Mood Test, Freund-Ansari-Bradley-David-Barton Test, Seigel-Tukey Test, Klotz-Normal Score Test, Sukhatme Test and Their Distributions Under Null Hypothesis, Moments Under Null Hypothesis.

Tests of Equality of k Independent Samples: Extension of Median Test, Kruskal-Wallis One-Way Anova Test, Distributional Properties of Each Test, Test Against Ordered Alternatives, Comparisons with Control.

Asymptotic Relative Efficiency (ARE): Concept of Pitman Efficiency, Theoretical Bases for Calculating ARE, Examples of Calculation of Efficacy and ARE.

References:

1. David, H. A. (1980): *Order Statistics*, 2nd edition, John Wiley, New York.
2. Gibbons, J. D. and Chakraborti, S. (1992): *Nonparametric Statistical Inference*, Marcel Dekker, Inc., USA.
3. Balakrishnan, N. and Cohen, A. C. (1990): *Order Statistics and Inference Estimation Method,* Academy Press, New York.
4. Conover, W. J. (1999): *Practical Nonparametric Statistics*, 3rd edition, John Wiley and Sons Inc., New York.
5. Hogg, R. V., Mckean, A. J. and Craig, A. T. (2007): *Introduction to Mathematical Statistics*, 6th edition, Pearson Education, Pte., Ltd., Singapore.

6. Mood, A. M., Graybill, F. A. and Bose, D. C. (1974): *Introduction to the Theory of Statistics*, 3rd edition, McGraw-Hill, New York.
7. Rohatgi V. K. and Saleh, A. K. M. E. (2001): *An Introduction to Probability and Statistics*, John Wiley and Sons Inc., New York.

STAT 4106
Research Methodology
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Basic Concepts of Research Methodology: Evaluation of Research and Research Methodology, Objectives, Importance of Research Methodology, Difference between Research Project and Research Program, Concepts, Meaning and Fundamental Difference of Method and Methodology, Concepts of Theory, Proposition, Concept and Hypothesis, Generation of Theory.

Research Design: Concepts of Research Design, Types of Research Design, Structured and Unstructured Research.
Exploratory Research Design: Methods of Exploratory Research.

Conclusive Research Design: Basic Idea of Conclusive Research Design, Types of Conclusive Research Design: Descriptive Research Design (Single, Multiple, Cross Sectional Design), Longitudinal Research Design, Causal Research Design.

Action Research: Concepts, Types, Steps in Conducting Action Research, Benefits of This Research; Fundamental Research on Mathematical Tools, Operation Research, Comparison among Basic Research Designs, Comparative Study of Cross Sectional and Longitudinal Studies.

Planning Research Design: Selection of Appropriate Research Design, Evaluation of Research Design, Questionnaire and Form Design.

Research Process: Basic Ideas, Steps Involved in Solving Research Problem; Concepts of Decision Making, Stages of Decision Making: Certainty, Uncertainty, Ambiguity.

Research Proposal: Purpose of Proposal, Research Benefits, Proposal Development, Types of Research Proposal, Structuring Research Proposal, Evaluation of Research Proposal.

Measurement and Scaling Concept: Rules for Measurement, Purpose of Scaling, Types of Scales, Criteria for Good Measurement: Reliability, Validity and Sensitivity, Difference between Reliability and Validity, Tests for Reliability, Different Measures of Validity.

Sampling Methods: Importance of Sampling in Social and Marketing Research, Different Sampling Techniques and Their Appropriateness, Criteria for Appropriate Sample Design, Determination of Sample Size of Mean, Proportion, Difference between Two Means and Correlation for Simple Random, Cluster, Stratified and Systematic Sampling; Errors in Survey Research: Responded Error and Administrative Error, Different Types of Response Bias.

Attitude Measurement: Components of Attitude, Elements of Measuring Attitude, Attitude as Hypothetical Construct, Techniques for Measuring Attitude, Scaling Techniques of Attitude; Comparative Scales and Non-Comparative Scales. Attitude Rating Scale, Simple Attitude Scale, Category Scale, Continuous Rating/Graphic Rating Scale, Itemized Rating Scale-Likert Scale, Semantic Differential Scale, Stapel,

Numerical Scale, Constant Sum Scale, Attitude Ranking Scale, Paired Comparison Scaling, Rank Order Scaling; Attitude Sorting Scale, Q-Sort Scaling.

Data Collection: Different Types of Data, Classification of Survey Methods, Selection of Appropriate Method for Data Collection, Secondary Data, Advantages and Disadvantages, Typical Objectives, Criteria for Evaluating Secondary Data, Sources as Secondary Data, Qualitative Research, Basic Concepts, Importance, Types.

Methods of Obtaining Qualitative Data: Direct Approach, Focus Group Discussion (FGD), Basic Ideas, Advantages and Disadvantages, Characteristics of Focus Group, Planning and Conducting Focus Group Interview, Two-Way FGD, Dual Moderator Group.
Depth Interviews Structure, Advantages, Disadvantages, Applications of Interview, Methods of Obtaining Data (Laddering, Hidden Issue Questioning, Symbolic Analysis), Indirect Approach, (Projective Technique, Association Technique, Completion Technique, Construction Technique, Expressive Technique).

Presentation of Data: Stages of Data Preparation Process, Preliminary Plan of Data Analysis, Questionnaire Checking, Editing, Coding, Transcribing, Data Cleaning, Statistically Adjusting Data, Selecting Data Analysis Strategy.

Measures of Association: Basic Concepts; Directional Measures, Lambda. Goodman and Kruskal Tau, Uncertainty Coefficient, Somers's d; Symmetric Measures, Phi, Cramer's V, Contingency Coefficient, Kendall's Tau-b, Kendall's Tau-c, Gamma.

Application of Dependence and Interdependence Techniques for Social and Marketing Data Analysis: Dependence Techniques, Multiple Regressions, Discriminant and Conjoint Analysis; Interdependence Techniques, Factor Analysis, Cluster Analysis, Multidimensional Scaling.

Report Preparation and Presentation: Literature Review, Importance and Function of Literature Review in Research, Steps in Writing Literature Review; Report Format, Report Writing, Guidelines for Tables and Graphs; Oral Presentation, Reading Research Report, Research Follow-Up.

References:

1. Malhotra, N. K. (2006): *Marketing Research*, 4th edition, Pearson Education, Singapore.
2. Zikmaund, W. G. (2000): *Business Research Methods,* 6th edition, Harcourt College Publishers.
3. Babbie, E. (2004): *The Practice of Social Research*, 10th edition, Thomson, Wadsworth.
4. Churchill, G. A. and Nielsen, A. C. (1995): *Marketing Research-Methodological Foundations*, 6th edition, Harcourt Brace College Publishers, New york.
5. Cooper, D. R. (1995): *Business Research Methods*, 5th edition, Irwin/McGraw-Hill Company, New York.
6. Dooley, D. (2001): *Social Research Methods*, 4th edition, Prentice Hall, India.
7. Trochim, W. M. K. (2006): *Research Methods*, 2nd edition, Biztantra, New Delhi.

STAT 4107
Statistical Data Analysis –XIX (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

DeterMining Euclidean and Statistical Distances, Constructing Contour, Assessing Multivariate Normality and Box-Cox Transformation of Multivariate Data, Construction of Confidence Region for Different Testing Problems, Analysis of Covariance Structure, Analysis of Data by MANOVA, Multivariate Regression Analysis, Logistic Analysis, Classification and Grouping Techniques of Data by Discrimination, Classification, Report Writing based on Practical Problem.

STAT 4108
Statistical Data Analysis –XX (Lab)
Full Marks-50
Number of Lectures: Minimum 15
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Drawing Probability Samples, Sampling with and without Replacement, Estimation of Population Characteristics and Variance of Estimators for Cluster Sampling, Double Sampling and Two Stage Sampling Methods, Allocation of Sample Sizes for Optimum Cost and Variance Function for Different Sampling Procedures, Drawing of Stratified Two-Stage Sampling and Estimation of Parameters, Report Writing based on Practical Problem.

STAT 4109
Statistical Data Analysis –XXI (Lab)
Full Marks-50
Number of Lectures: Minimum 20
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Problems Related to Course STAT 4104.

STAT 4201
Multivariate Analysis
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Principal components: Definition and Objective of Principal Component Analysis (PCA), Distribution of i-th Principal Component, Proportion of Total Population Variance due to k-th PC, PC for Standardized Variable, Graphing PC, Test for Equal Correlation Structure.

Independent Component Analysis (ICA): Basic Concept on ICA: Definition, Identifiability of the ICA Model, Ambiguities of ICA, Preprocessing of ICA: Centering, Whitening, Principles of ICA Estimation: Maximization of non-Gaussianity using kurtosis and Negentropy, Minimization of Mutual Information, Maximum Likelihood Estimation.

Factor Analysis: Definition and Purposes of Factor Analysis, Its Relation with PCA and MR Model, Meaning of Orthogonal Factor Model, Cumulative Factor, Specific Factor, Loading Covariance Structure for Orthogonal Factor Model, Principal Component, and Principal Factor, ML Method of Parameter Estimate of PC Model, Large Sample Test for Number of Common Factors, Oblique, Variance and Oblique Rotation. Definition and Elements of Factor Scores, Estimating Factor Scores by WLS and Regression Methods. Best Strategy from FA.

Cluster Analysis: Meaning and Objectives of Clustering, Different Similarity Measures, Euclidean Distance, Statistical Distance, Minkowski, Canberra, Hierarchical Clustering Method, Non-Hierarchical Method.

Discrimination and Classification Analysis: Meaning and Goals of Discrimination and Classification, Method of Discrimination and Classification, Problems of Classification, Expected Caused and Total Probability of Misclassification, Minimum Cost Region, Classification with Two-Multivariate Normal Population, Fisher Discrimination Function.

References:

1. Johnson, R. A. and Wichern, D. W. (2002): *Applied Multivariate Statistical Analysis,* 5th edition, Pearson Education, Asia.
2. Anderson, T. W. (1984): *Introduction to Multivariate Analysis*, 2nd edition, John Wiley, New York.
3. Mardia, K. V., Kent, J. T. and Bibby, J. M. (1979): *Multivariate Analysis,* Academic Press, London.
4. Hyv̈arinen , A. Karunen, J. and Oja, E. (2001): *Independent Component Analysis*, New York: Wiley.

STAT 4202
Economic Statistics and Econometrics
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Introduction: Origin and scope of economic statistics and econometrics, Goals of econometrics, division of econometrics, econometrics for policy analysis.

The distribution of personal income: Introduction, some empirical income distributions, Pareto's law, the log normal distribution.

The analysis of family budget: Consumer's survey, limitations of budget surveys, the use of group means, the Engel curve, quality variation, household composition.

Econometric Modeling: Average Economic Regression, Methodology and Specification Errors, Types of Specification Error, Nature, Consequences and Remedies of Specification Errors, Test of Specification Error, Errors of Measurement in Dependent and Explanatory Variables, Monte-Carlo Experiment of Specification Error.

The general simultaneous equation model: Identification of a structural equation, estimation of simultaneous equation systems, OLS and LS bias, indirect least squares, two stage least squares, three stage least squares, examples of simultaneous equation models, supply-demand model, Klein-Goldberger model, the revised Klein-Goldberger model, Money demand-supply model, models of the Bangladesh economy.

Demand Analysis: Introduction, the origin of demand analysis, the basic model, Schultz's method, the estimation of price flexibilities, single-commodity studies, dynamic demand analysis.

The production function: Introduction, the economic model, the statistical model, the Cob-Douglas production function, the elasticity of substitution, the C.E.S production function, Translog function.

Non-Linear Least Squares: Non-Linear Model and Principles of Non-Linear Least Squares Estimation, Numerical Method of Estimating Least Squares, Properties of Non-Linear Regression, Cobb-Douglas and CES Production Functions, Estimation of Cobb-Douglas Production Function Parameters.

Input-Output Analysis, Internal Efficiency, Inter Industry Relation, Application of Social Accounting Matrix in Planning and Development.

References:

1. Bridges, J.L.: *Applied Econometrics,* North-Hottand, Amsterdam.
2. Desai, M. (1976): *Applied Econometrics,* Oxford Publication.
3. Johansen, L. (1972): *Dynamic Production Function,* North-Holland.
4. Mukhopadhayaya, P. (1999): *Applied Statistics,* Books and Allied Ltd., India
5. Prais S.J. and Houthakker H.S. (1971): *The Analysis of Family Budgets,* Cambridge University Press, London.
6. Schultz, H. (1938): *The Theory and Measurement of Demand,* University of Chicago Press, Chicago.
7. Theil, H. (1961): *Economic Forecasts and policy,* North Holland, Amsterdam.
8. Klein, L. R. (1974): *A Text Book of Econometrics,* Evanston, Ill., Row, Peterson Stats.

STAT 4203
Epidemiology and Survival Analysis
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Overview: Definition, Scope of Epidemiology, Uses of Epidemiology.

Causation in Epidemiology: Concept of Cause, Establishing Cause of Disease.

Types of Epidemiological Studies: Cross Sectional, Cohort, Case-Control, Retrospective and Prospective, Clinical Trials, Community Intervention and Cluster Randomized Trials.

Measures of Disease Frequency: Incidence and Prevalence Rates, Relation between Incidence and Prevalence, Case Fatality Rate, Risk Ratio, Rate Ratio, Risk Difference, Rate Difference, Mortality Measures, Standardized Mortality Ratio.

Measures of Association between Disease and Risk Factor: Relative Risk, Attributable Risk, Odds Ratio.

Epidemiology and Prevention: Scope of Prevention, Levels of Prevention: Primordial, Primary, Secondary and Tertiary.
Screening, Properties of Screening Test: Sensitivity, Specificity, Negative and Positive Predictive Values.

Scope of BioStatistics: Probability Density Function, Survivor Function, Hazard Function, Their Inter Relationships; Censoring and Truncation; Type I, Type II and Random Censoring; Likelihood Functions Under Different Types of Censoring, Survival Distributions: Exponential, Weibull, Extreme Value, Gamma, Lognormal.

Non-Parametric Methods of Estimating Survivor Functions: Life Table Method, Product Limit Method, Variance Estimates, Cumulative Hazard Function, Plots Involving Estimated Survivor and Hazard Functions; Non Parametric Methods for Comparing Survival Distributions: Gehan's Generalized Wilcoxon Test, Mantel-Haenszel Test.

Inference Procedures: One Parameter Exponential Distribution with Type I and Type II Censored Data, Comparison of Exponential Distributions, Two Parameter Exponential Distribution with Type I and Type II Censored Data, Inference Procedures for Weibull and Extreme Value Distributions with Type I and Type II Censored Data.

Parametric Regression: Poisson Regression Model, Exponential Regression Model, Proportional Hazards model, Proportional odds model, Conditional likelihood, Partial likelihood, Marginal likelihood, Logistic Regression, Method of Estimation, Tests of Hypothesis.

References:

1. Barker, D. J. P. and Hall, A. J. (1991): *Practical Epidemiology,* Churchil Living Stone, Edinburg.
2. Daniel, W. W. (2000): *Bio-Statistics: A Foundation for Analysis in the Health Science*, 7th edition, John Wiley and Sons, New York.
3. Fienberg, S. F. (1980): *The Analysis of Cross-Classified Categorical Data*, 2nd edition, The MIT Press, New York.
4. Indrayan, A. and Sarmukaddam, S. B. (2001): *Medical Biostatistics*, Marcel Dekkar, USA.
5. Kalbflesch, J. D. and Prentice, R. L. (1980): *The Statistical Analysis of Failure Time Data*, John Wiley, New York.
6. Kenneth, J. and Rothman, S. G. (1998): *Modern Epidemiology*, 2nd edition, Lippin Catt.
7. Khan, A. Q. (1999): *Epidemiology and Disease Control*, 2nd edition, Dhaka.
8. Lawless, J. F. (2003): *Statistical Models and Methods for Life Time Data*, 2nd edition, Wiley Series, New York.
9. Lee, E. T. (1992): *Statistical Methods for Survival Data Analysis*, 2nd edition, Wiley Series, New York.
10. McCullah, P. and Nelder, J. A. (1982): *Generalized Linear Models*, Chapman and Hall, London.
11. Newman, S. (2001): *Biostatistical Methods in Epidemiology*, Wiley, New York.
12. Sahai, H. and Khurshid, A. (1995): *Statistics in Epidemiology, Methods, Techniques and Applications*, CRC Press, Boca Raton, Florida.

STAT 4204
Data Mining
Full Marks-100
Number of Lectures: Minimum 30
Duration of each lecture: 1.5 hours
Duration of Examination: 3 hours

Overview: Meaning of Data Mining and Knowledge Discovery, Basics, Data Mining Tasks, Classification, Regression, Time Series Analysis, Prediction, Clustering, Summarization, Association, Rules, Sequence Discovery, Development of Data Mining, Data Mining Issues and Mining Metrics, Social Implications of Data Mining.

Related Concepts of Data Mining: Fuzzy Sets: Introduction, Classical Set, Set Operation, Boolean Logic, Basic Concepts of Fuzzy Sets, Other Representations of Fuzzy Sets, Determination of Membership Functions, Fuzzy Sets Properties, Operations on Fuzzy Sets, Logic Operations, Algebraic Operations on Fuzzy Sets.

Fuzzy Relation: Classical Relations, Classical Reasoning, Fundamentals of Fuzzy Relations, Operations on Binary Fuzzy Relations, Types of Fuzzy Relations, Fuzzy Reasoning, Concluding Remarks, Bibliography, Web Resources.

Database/OLTP Systems: Logic, Information Retrieval, Decision Support Systems, Dimensional Modeling, Multidimensional Schemas, Indexing, Data Warehousing, OLAP, Web Search Engines, Statistics, Machine Learning, Pattern Matching.

Data Mining Techniques: Statistical Perspective on Data Mining: Point Estimation, Models based on Summarization, Bayes Theorem, Hypothesis Testing, Regression and Correlation. Similarity Measures, Decision Tree, Genetic Algorithms.

Neural Network: Background, Learning, Basic Neuron Model, Perception, Multiplayer Perception, Recurrent Network, Hop field Network, Boltzanann Machine Network, Kohonen Self-Organizing Network, Background, Description, DeterMining the Winning Neuron, Learning Algorithm.

Classification: Issues in Classification, Statistical-based Algorithms, Regression, Bayesian Classification, Distance-based Algorithms, K-Nearest Neighbors, Decision Tree-based Algorithms, ID3, C4.5, C5.0, CART, Neural Network-based Algorithms, Propagation, NN, Supervised Learning, Radial Basis Function Network, Perceptrons, Rule-based Algorithms, Generating Rules from DT, Generating Rules from Neural Net.

Clustering: Similarity and Distance Measures, Outliers, Hierarchical Algorithms, Agglomerative Algorithms, Divisive Clustering, Partitional Algorithms, Minimum Spanning Tree, Squared Error Clustering Algorithm, K-Means Clustering, Nearest Neighbor Algorithm, PAM Algorithm, Bond Energy Algorithm, Clustering with Genetic Algorithms, Clustering with Neural Networks, Clustering Large Databases, Clustering with Categorical Attributes**.**

Association Rules: Meaning of Association, Large Item Sets, Basic Algorithms, Apriori Algorithm, Sampling Algorithm, Partitioning, Parallel and Distributed Algorithms, Data Parallelism, Task Parallelism, Advanced Association Rule/Technique, Quantitative Association Rules, Correlation Rules, Measuring Quality of Rules.

Web Mining: Web Content Mining, Crawlers, Harvest System, Virtual Web View, Personalization, Web Structure Mining, Page Rank, Clever, Web Usage Mining, Preprocessing, Data Structures, Pattern Discovery, Pattern Analysis.

References:

1. Dunham, M. H. (2003): *Data Mining*, Pearson Education, Asia.
2. Ibrahim, A. M. (2004): *Fuzzy Logic for Embedded Systems Applications*, Elsevier Science, USA.
3. Larose, D. T. (2006): *Data Mining: Methods and Models*, Wiley-Interscience, India.
4. Schalkoff, R. (2005): *Pattern Recognition Statistical, Structural and Neural Approaches*, John Wiley and Sons, New York.

STAT 4205
Statistical Data Analysis-XXII (Lab)
Full Marks-50
Number of Lectures: Minimum 20
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Problems Related to Course STAT 4201.

STAT 4206
Statistical Data Analysis-XXIII
Full Marks-50
Number of Lectures: Minimum 20
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Fitting Engel Functions to Family Budget Data, Estimation of Aggregate Demand function from Time Series Data, Fitting Pareto's Law and Lognormal Distribution to Personal Incomes, Determination of Concentration Ratio from Lorenz Diagram, Fitting of CD Production Function and CES Production Functions, Analysis of Time Series Data: Test of Randomness, Determination of Trend, Seasonal and Cyclical Components, Forecasting and Prediction, Solution of the problems using Computer programs and packages.

STAT 4207
Statistical Data Analysis –XXIV (Lab)
Full Marks-50
Number of Lectures: Minimum 20
Duration of each lecture: 1.5 hours
Duration of Examination: 2 hours

Plots Involving Estimated Survivor and Hazard Functions, Probability Plots, Cross Product Ratio, Prevalence Rate, Incidence Rate, Non-parametric Estimation of survival probabilities and their Standard errors from ungrouped and grouped data, Construction of survival curves and their confidence belts, Graduation of life data (Censored and uncensored) by plotting procedures, Fitting of appropriate parametric model (one parameter exponential, two parameter exponential and Weibull) to observed data and testing goodness of fit of fitted models (Kolmogorov- Smirnov test, L.R. test), Construction of confidence limits for life parameters for the fitted models, Analysis of screening tests, Estimation of sensitivity and potency of test preparation through Indirect and Direct Assays, Computations of attributable and relative Risks - odds Ratio Analysis with standard Errors and confidence Interval of odds Ratios, Graphical Solutions of two variable problems, Report Writing based on Practical Problem.

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Statistical Data Analysis –XXV (Lab)
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Problems related to STAT 4204.