

**Department of Statistics**  
**Jahangirnagar University**

**Syllabus for B.Sc. (Hons.) in Statistics.**  
**Session 2015-2016, 2016-2017, 2017-2018 and 2018-2019**

The Bachelor of Science (B.Sc.) Honors program in Statistics fosters at specializing and training in statistical methodology in its theoretical, practical/applied, and in scientific research aspects of modern age particularly with computer intensiveness.

This program shall extend over a period of four academic years that is divided into four levels viz: Part I, Part II, Part III and Part IV. Each part denotes one academic year (July to June). The courses offered in this program are of theoretical and practical nature. The total units of courses is 34, totaling 3400 marks, of which 25½ units are theoretical courses, 6 units are practical courses, ½ unit for project report and 2 units of viva-voce.

Part	Nature of course	Units	Credit Hours	Marks
I	Theoretical	5 ½	22	550
	Practical	1	4	100
	Viva-voce	½	2	50
II	Theoretical	6	24	650
	Practical	1	4	100
	Viva-voce	½	2	50
III	Theoretical	6 ½	26	650
	Practical	2	8	200
	Viva-voce	½	2	50
IV	Theoretical	7½	30	700
	Practical	2	8	200
	Viva-voce	½	2	50
	Report	½	2	50
<b>Total</b>		<b>34</b>	<b>136</b>	<b>3400</b>

The class attendance carries 10% of the total marks in all courses (theoretical and practical). The course-end examinations carry 70% marks both in theoretical and practical courses, while 20% of the total marks are allocated for tutorial examinations that spread through the whole academic year. The students shall have to submit a report carrying 50 marks at the end of the Part IV (fourth year). The topic of which shall be approved by the Chairperson of the Department on the recommendation of the research supervisor, which shall be submitted on or before the day that are fixed by the Part IV examination committee. At the end of all course examinations in each academic year students shall have to face an interview board for viva-voce that carries 50 marks.

The assessment of students in a particular course will be based on the marks obtained in the (i) class works in the form of class attendance and tutorials, and (ii) course-end examinations. The course-end examinations shall be held at the end of the First Year, Second Year, Third Year and Fourth Year, respectively.

The year-wise structure for the B.Sc. (Honors) program is given below:

**Part I**

Course Code	Course Title	Marks	Credit
<u>Theoretical Course</u>			
STAT-101	Introductory Statistics	100	4
STAT-102	Elementary Probability	50	2
STAT-103	Linear Algebra	100	4
STAT-104	Introduction to Computer and Computer Programming	100	4
STAT-105	Numerical Analysis	50	2
STAT-106	Algebra and Calculus with Analytical Geometry	100	4
STAT-107	Microeconomics and Economic Statistics	50	2
<u>Practical Courses</u>			
STAT LAB -108	Statistical Data Analysis I	50	2
STAT LAB -109	Statistical Data Analysis II	50	2
	Viva-Voce	50	2
<b>Total</b>		<b>700</b>	<b>28</b>

**Part II**

Course Code	Course Title	Marks	Credit
<u>Theoretical Courses</u>			
STAT-201	Probability Distribution	50	2
STAT-202	Sampling Distribution	100	4
STAT-203	Regression Analysis	100	4
STAT-204	Demography	50	2
STAT-205	Quality Control and Educational Statistics	50	2
STAT-206	Macroeconomics and Economic Statistics	50	2
STAT-207	Mathematical Analysis and Differential Equations	100	4
STAT-208	Data Processing and Statistical Simulation	100	4

<u>Practical Courses</u>			
STAT LAB -209	Statistical Data Analysis III	50	2
STAT LAB -210	Statistical Data Analysis IV	50	2
	Viva-Voce	50	2
<b>Total</b>		<b>750</b>	<b>30</b>

### Part III

<b>Course Code</b>	<b>Course Title</b>	<b>Marks</b>	<b>Credit</b>
<u>Theoretical Courses</u>			
STAT-301	Statistical Inference I	100	4
STAT-302	Analysis of Variance	50	2
STAT-303	Sampling Techniques I	50	2
STAT-304	Operations Research	50	2
STAT-305	Research Methodology	50	2
STAT-306	Econometrics	100	4
STAT-307	Time Series Analysis	100	4
STAT-308	Actuarial Statistics	50	2
STAT-309	Environmental Statistics	50	2
STAT-310	Data Processing with Statistical Software	50	2
<u>Practical Courses</u>			
STAT LAB –311	Statistical Data Analysis V	100	4
STAT LAB –312	Statistical Data Analysis VI	50	2
STAT LAB –313	Statistical Data Analysis VII	50	2
	Viva-Voce	50	2
<b>Total</b>		<b>900</b>	<b>36</b>

### Part IV

<b>Course Code</b>	<b>Course Title`</b>	<b>Marks</b>	<b>Credit</b>
<u>Theoretical Courses</u>			
STAT-401	Statistical Inference II	100	4
STAT-402	Multivariate Analysis	100	4
STAT-403	Design of Experiments	100	4
STAT-404	Sampling Techniques II	50	2
STAT-405	Data Mining	50	2
STAT-406	Epidemiology and Biostatistics	100	4
STAT-407	Advanced Demography	50	2
STAT-408	Stochastic Process	50	2
STAT-409	Bioinformatics	50	2
STAT-410	Categorical Data Analysis	100	4
<u>Practical Courses</u>			
STAT LAB –411	Statistical Data Analysis VIII	50	2
STAT LAB –412	Statistical Data Analysis IX	50	2
STAT LAB –413	Statistical Data Analysis X	50	2
STAT LAB –414	Statistical Data Analysis XI	50	2
	Project Report	50	2
	Viva-Voce	50	2
<b>Total</b>		<b>1050</b>	<b>42</b>
<b>Grand Total</b>		<b>3400</b>	<b>136</b>

## Part I

### **STAT-101: Introductory Statistics**

**1 Unit/4 Credit (at Least 50 Class Hours)**

**Statistics:** History, Definition, Nature, Scope and Classification of Statistics; it's Relation with other Disciplines, Limitations, uses, Misuses, and Abuses of Statistics.

**Processing of Data:** Variables and Attributes, Types of Variables, Population and Sample, Different Scales: Cardinal, Ordinal, Interval and Ratio, Source of Data, Classification and Tabulation of Data, Frequency Distribution, Graphical Representation of Data, Stem and Leaf Display, Dot Plot, Time Series Plot.

**Measures of Central Tendency:** Mean, Median, Mode, Geometric Mean, Harmonic Mean, Trimmed Mean, Quadratic Mean with their Properties, Quantiles, Application of Measures of Central Tendency.

**Measures of Dispersion:** Absolute and Relative Measures of Variability, Application of Different Measures of Dispersion.

**Moments and Shape Characteristics of Distribution:** Moments, Sheppard's Corrections for Grouping Error, Skewness and Kurtosis, Box-Plot.

**Simple Correlation and Regression:** Bivariate Data, Scatter Diagram, Simple Correlation, Correlation Ratio, Rank Correlation, Simple Linear Regression Analysis.

**Contingency Table:** Association of Attributes, Coefficient of Association, Total Association, Partial Association, Manifold Classification, Coefficient of Contingency, Pearson's Coefficient of Mean-Square Contingency.

**Index Number:** Basic Concepts, Problem of Index Number, Different Types of Indexes, Errors in Index Number, Different Formulae, Tests of Index Numbers, Cost of Living Index.

**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.

#### **Texts**

1. Allan G. Bluman, (2013): *Elementary Statistics: A Step By Step Approach*, 9<sup>th</sup> Edition. Mcgraw Hill Inc.

#### **References**

1. Lind, A. D., Marchal, W. and Wathen, S. (2014): *Statistical Techniques in Business and Economics*, 16<sup>th</sup> Edition, Mcgraw Hill Inc.
2. Yule, G. U. and Kendall, M. G. (1999): *An Introduction to the Theory of Statistics*, Universal Book Stall, New Delhi.
3. Newbold, P., Carlson, W. L. and Throne, B. M. (2013): *Statistics for Business and Economics*, 8<sup>th</sup> Edition, Pearson Education Ltd.

### **STAT-102: Elementary Probability**

**½ Unit/2 Credit (at Least 35 Class Hours)**

**Basic Concept of Probability:** Sample Space, Event, Event Space and Different Types of Events, Classical, Empirical, Geometric, Relative Frequency and Axiomatic Methods of Probability, Odds Ratio, Probability Measures and Probability Space, Total Probability, Tree Diagrams and Compound Probability, Conditional Probability, Prior and Posterior Probability, Bayes' Theorem.

**Random Variable:** Probability Space, Concept of Random Variable, Discrete and Continuous Random Variables, Probability Function, Distribution Function, Function of Random Variable and its Distribution, Joint, Marginal and Conditional Distributions, Independence of Random Variables.

**Expectation:** Meaning of Expectation and Conditional Expectation, Mean, Expectation of a Function of a Random Variable, Variance, Conditional Mean and Conditional Variance, Moments, Covariance and Correlation Coefficient, Expectation of Sums and Products of Random Variables, Chebyshev's Inequality.

**Generating Function:** Moment Generating Function, Characteristic Function, Probability Generating Function, Cumulant Generating Function and Their Properties, Inversion Theorem, Convolution.

**Probability Distribution:** Concepts of Bernoulli, Binomial, Poisson, Uniform and Normal.

#### **Text**

1. Ross, S. (2014): *A First Course in Probability*, 9<sup>th</sup> Edition, Pearson Education Inc.

#### **References**

1. Devore, J. L. (2016): *Probability and Statistics for Engineering and the Science*, 9<sup>th</sup> Edition, Cengage Learning.
2. Mood, A. M., Graybill, F. A. and Boes, D. C. (1974): *Introduction to the Theory of Statistics*, 3<sup>rd</sup> Edition, Mcgraw-Hill, New York.
3. Hines, W. W., Montgomery, D. C., Goldsman, D. M. and Borror, C. M. (2003): *Probability and Statistics in Engineering*, 4<sup>th</sup> Edition, Wiley.

## STAT-103: Linear Algebra

1 Unit/4 Credit (at Least 50 Class Hours)

**Vector:** Introduction to Vector (Geometric), Norm of Vector, Vector Arithmetic, Dot Product, Projection, Cross Product, Lines and Planes In 3-Dimensional Space, Euclidean  $N$ -Space, Cauchy-Schwarz Inequality, Triangle Inequality, Linear Transformations from  $R^n$  to  $R^m$ , Reflection Operators, Projection Operators, Rotation Operators, Compositions of Linear Transformations, Properties of Linear Transformations.

**Vector Space:** Vector Space, Axioms, Subspaces, Linear Combination, Span, Space Spanned, Linearly Independent, Geometric Interpretation of Linear Independence and Dependence, Basis, Standard Basis, Dimension, Row Space, Column Space, Null Space.

**Inner Product Space:** Inner Product, Angle and Orthogonality in Inner Product Space, Orthonormal Bases – Gram-Schmidt Process, QR-Decomposition.

**Matrix and Matrix Operations:** Definition of Matrix, Matrix Operations and their Properties, Different Types of Matrices: Square, Identity, Scalar, Diagonal, Null, Symmetric, Skew-Symmetric, Orthogonal, Unitary, Hermitian, Skew-Hermitian, Idempotent, Nilpotent and Involutory, Random, Variance-Covariance and Correlation, Product, Kronecker Products, Partition of Matrices, Matrix Products as Linear Combinations, Transpose of Matrix, Trace of Matrix.

**Determinant:** Meaning, Properties of Determinant, Determinant by Cofactor Expansion, Minors, Cofactors, Adjoint, Combinatorial Approach to Determinant, Evaluating Determinant by Row Reduction.

**Rank and Inverse Matrix:** Rank and Elementary Transformations of Matrices, Related Theorems of Ranks, Diagonal Reduction of Matrix, Adjoint, Inverse, Generalized Inverse of Matrix, Properties of Inverse, Matrix Inequalities and Maximization, Canonical and Normal form of Matrix, Linear Function of Matrices, Integration of Matrices, Elementary Matrices.

**Solution of System of Linear Equation:** Introduction to Systems of Linear Equations, Different Methods - Elementary Row Operations, Row-Echelon form, Reduced Row-Echelon form, Gaussian Elimination, Gauss-Jordan Elimination, Matrix Inversion, Cramer's Rule, Homogeneous and Non-Homogeneous Systems.

**Eigenvalues and Eigenvectors:** Definition of Eigenvalues and Eigenvectors, Diagonalization, Orthogonal Diagonalization.

**Characteristic Value Problem and Quadratic form:** Characteristic Value Problem, Similarity, Characteristic Roots and Vectors of Matrix, Theorems of Characteristic Roots and Vectors: Cayley-Hermiton Theorem, Finding Square Root of Square Matrix, Spectral Decomposition, LU-Decomposition: Solving Linear System by Factorization, Classifications and Identification of Quadratic forms: Positive and Negative Definite, Positive and Negative Semidefinite and Indefinite Matrices, Diagonalization of Quadratic Forms, Reduction of Quadratic forms, Related Theorems, Derivatives of Quadratic form with Respect to Vector.

### Text

1. Anton, H. and Rorres, C. (2014): *Elementary Linear Algebra*, 11<sup>th</sup> Edition, Wiley.

### References

1. Ayres, F. (1982): *Theory and Problems of Matrices*, Mcgraw-Hill, New York.
2. Basilevsky, A. (1982): *Schaum's Outline of Theory and Probability of Matrices*, Mcgraw-Hill, Singapore.
3. Johnson, R. A. and Wichern, D. W. (2007): *Applied Multivariate Statistical Analysis*, 6<sup>th</sup> Edition, Prentice-Hall International, USA.

## STAT-104: Introduction to Computer and Computer Programming

1 Unit/4 Credit (at Least 50 Class Hours)

### Part A: Introduction to Computer

**Computer Basics:** Structure, History, Characteristics and Functions of Computer, Criteria of Powerful Computer, Classifications and Generations of Computer, Computer System, Parts of Computer Hardware.

**Processing Data:** Presentation of Data by Computers, Bits and Bytes, Text Codes Data, Processing of Data by Computer, CPU-Control Unit, ALU and Registers, Factors Affecting the Processing Speed of Computer, Memory: Main and Auxiliary Memory, Storage Devices. RAM, ROM.

**Input and Output Devices:** Keyboard, Mouse, Monitor, Printer, Tape, Disk, CD, DVD, Pendrive, Scanner, Digital Cammera Etc.

**Number System:** Basic Concept, Binary, Octal, Decimal and Hexadecimal Number System, Conversion of Data Using Number System, ASCII.

**Operating System:** Meaning of Operating System, Functions of Operating System.

**PC Operating System:** DOS, UNIX, LINUX, Window Base OS-Macintosh Operating System, OS/2 Warp, Windows NT, Windows 2000 Professional, Windows 2000/2003 Server, Windows XP, Windows NET, Vista, Windows 7, Windows 8.1, Windows 10.

**DOS:** Meaning of DOS, Difference Between PC-DOS and MS-DOS, DOS Prompt, Base Name and Extension, Command Line, Difference Between File and Directory (Root and Subdirectory), DOS Wild Character, Read Me and Executable Files, Different Internal and External Commands.

**LINUX Operating System:** Basic Concept, History of LINUX, Current Applications, Starting and Stopping, User Interface, Logging in, Activating User Interface and Logging Out, General Overview of File System - Manipulating Files and File Security, Copying,

Deleting and Viewing Files, Multitasking, Managing and Scheduling Processes, Linux in Office, Networking with Linux, Installing Software for Linux, Printing Files.

**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, Satellite, Wi-Fi.

**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, Cookies.

### **Part B: Computer Programming Language C**

Fundamental of C, Component of C Program, Declare Variable and Assign Values, Function, C Keywords, Program Control Statements: if, Else, for, Loop, Incremental, Decrement, Printf, Relation and Logical Operators, Input Characters, while Loop, Create Nested Loop, Break, Continue, Switch, Goto. Data Types, Variable and Expressions, Arrays and Strings, Pointers, Function Prototypes, Main (), Console I/U and File I/U.

#### **Texts**

1. Norton, P. (2006): *Introduction to Computers*, 6<sup>th</sup> Edition, Tata Mcgraw-Hill Publishing Company Ltd., New Delhi.
2. Balagurusamy E.(2012): *Programming in ANSI C*, 6<sup>th</sup> Edition, Tata Mcgraw-Hill Publishing Company Ltd., New Delhi

#### **References**

1. Rajaraman, V. and Adabala, N. (2014): *Fundamentals of Computers*, 6<sup>th</sup> Edition, Prentice Hall, India.

### **STAT-105: Numerical Analysis**

**½ Unit/2 Credit (at Least 35 Class Hours)**

**Introduction:** Difference Effect of an Error in a Tabular Value, Relation between Difference and Derivatives, Difference of Polynomials, Concept of Interpolation, and Newton's Interpolation Formula.

**Central Difference Interpolation Formula:** Gauss Formula, Stirling's Formula and Bessel's Formula.

**Interpolation with Unequal Intervals:** Divided Difference Formula, Newton's General Interpolation Formula, Lagrange's Formula.

**Inverse Interpolation:** Lagrange's 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 to Numerical Equation:** Bisection Method, Method of False Position, Newton-Rapson Method, Method of Iteration.

#### **Text**

1. Scarborough, J. B. (1966): *Numerical Mathematical Analysis*, 6<sup>th</sup> Edition, Oxford and IBH, New Delhi.

#### **References**

1. Sastry, S. (1997): *Introductory Methods of Numerical Analysis*, 2<sup>nd</sup> Edition, Prentice-Hall, New Delhi.
2. Sauer, T. (2011): *Numerical Analysis*, 2<sup>nd</sup> Edition, Pearson Education Ltd.

### **STAT-106: Algebra and Calculus with Analytical Geometry**

**1 Unit/4 Credit (at Least 50 Class Hours)**

#### **Group A: Algebra**

**Boolean Algebra:** Concept, Basic Properties, Derived Properties, Boolean Functions, Boolean Multiplication, Boolean Addition.

**Real Number System:** Number System, Natural Numbers, Integers, Prime Numbers, Rational Numbers, Irrational Numbers, Real Numbers, Imaginary Numbers.

**Relations and Functions:** Graph of Relations and Functions, Distance Formula and the Circle.

**Groups, Ring and Field:** Binary Composition, Various Types of Compositions, Groups, Properties of Group, Modulo, Rings, Fields. Linear, Quadratic, Cubic and Higher Order Equations.

**Logic and Language of Proof:** Tautologies, Mathematical Proof by Contradictions Method, Contra Positive Method, Iterative Method, Mathematical Induction.

#### **Group B: Analytical Geometry**

**Systems of Coordinates:** Concept of Cartesian Coordinates, Directed Line, Directed Distance, Undirected Distance, Slope of Line, Slope Formula, Parallel and Perpendicular Line, Three Dimensional Cartesian Coordinates, Concept of Polar Coordinates; Curve-Equation Relationship, Curve Sketching in Polar Coordinates, Symmetry of Curve with Line, Tangents to Polar Curves, Areas in Polar Coordinates, Arc Length in Polar Coordinates.

**Lines and Planes:** Equations of Line, Symmetrical form of Equations, Line Through Two Points, Direction Cosines, Direction-Ratios from Equations, Reflection, Projection, Rotation, Angle Between Translation of Axis, Locus Equation of Plane, General Equation of Plane, Plane through Three Given Points, Distance from a Point to Plane, Planes Bisecting Angles Between Given Planes, Intersection of Three Planes, Line Intersecting Two Given Lines, Coplanar Lines, Distance between Two Lines.

**Circle:** Equation of Circle, Related Theorems on Circle, Locus of Circle, Determining Coefficients, Translation of Circle.

**Parabola:** Definition, Equation of Parabola, Parabola as Reflector.

**Ellipse:** Definition, Equation of Ellipse, Reflection Property, Chord of an Ellipse, Tangent of an Ellipse, Normal to an Ellipse, Diameters, Algebraic Parameter for an Ellipse.

**Hyperbola:** Definition, Chord and Tangent, Equation of Hyperbola, Asymptote, Common Properties of Parabola, Ellipse, and Hyperbola; Parabola, Hyperbola, and Ellipse as Conic Sections.

### Group C: Calculus

Relation, Functions, Domain, Range and Their Graphs for Real Numbers, Graphs of Functions Like Exponential and Logarithmic, Trigonometric etc., Inverse Function, Limits and Continuity, Intermediate form, Tangents and Normal. Sandwich Theorem.

Differentiability, Derivative Techniques, Shapes and Application of Different Differentiation, Asymptotes, Higher Derivatives, Chain Rule Implicit Differentiation, Leibnitz Theorem, Partial Derivatives; Euler's Theorem, Intermediate forms, Tangents, Normal (Including Polar Coordinates), L-Hospital's Rule, Rolle's Theorem, Mean Value Theorem, Residue Theorem, Maxima and Minima, Extrema; Curve Sketching (Graphs): Algebraic Clues-Symmetry Criteria, Intercepts, First Derivative-Maxima, Asymptotes, Minima, Second Derivative-Concavity, Points of Inflection.

Integral Techniques, Method of Substitution, Integration by Parts, Application of Integration; Definite Integral as Limit of Sum, Interpretation as Area, Fundamental Theorem of Integral Calculus (for Continuous-Functions), Determination of Length and Area, Reduction Formulae, Multiple Integrals Like Double Integral, Triple Integral, etc., Jacobian, Taylor's Theorem, Maclaurian's Theorem, Beta and Gamma Functions, Improper Integrals.

#### Texts

1. Anton, H. (1995): *Calculus with Analytic Geometry*, 5<sup>th</sup> Edition, Wiley, New York.

#### References

1. Apostol, T. M. (1967 and 1969): *Calculus*, Vol. I and II, 2<sup>nd</sup> Edition, John Wiley and Sons, New York.
2. Ayres, F. and Meldelson, E. (2013): *Schaum's Outlines Calculus*, 6<sup>th</sup> Edition, Mcgraw-Hill, New York.
3. Buck, R. C. (1978): *Advanced Calculus*, 3<sup>rd</sup> Edition, Mcgraw-Hill, New York.
4. Lang, S. (1986): *First Course in Calculus*, 5<sup>th</sup> Edition, Springer-Varlag, New York.
5. Maxwell, E. A. (1958): *Elementary Coordinate Geometry*, 2<sup>nd</sup> Edition, Oxford University Press, London.
6. Thomas, G. B. and Finney, R. L. (1996): *Calculus and Analytic Geometry*, 9<sup>th</sup> Edition, Addison-Wesley Publishing Company, Inc.
7. Aggarwal, R. S. (1973): *A Text Book on Modern Algebra*, S. Chand and Co., New Delhi.
8. Khanna V. K. (2004): *Lattices and Boolean Algebras*, 2<sup>nd</sup> Edition, Vikas Publishing House Pvt., New Delhi.

### STAT-107: Microeconomics and Economic Statistics

½ Unit/2 Credit (at Least 35 Class Hours)

**Introduction:** Meaning of Economics, Distinguish between Microeconomics and Macroeconomics, Two Big Questions of Economics, Key Ideas that Defined Economic Way of Thinking, Production Possibility Frontier, Opportunity Cost.

**Demand, Supply and Price:** Determinants of Demand and Supply, Laws of Demand and Supply, Movements along and Shift of Demand and Supply Curves, Equilibrium Price and Quantity, Concept of Elasticity of Demand and Supply.

**Utility and Demand:** Consumption Choices: Consumption Possibilities, Preferences, Budget Line, Meaning of Utility, Total Utility, Marginal Utility, Law of Diminishing Marginal Utility, Consumer Equilibrium, Marginal Utility Per Dollar, Utility Maximizing Rule, Predictions of Marginal Utility Theory, Paradox of Value.

**Possibilities, Preference and Choice:** Consumption Possibilities, Preferences and Indifference Curves, Marginal Rate of Substitution, Diminishing Marginal Rate of Substitution, Degree of Substitutability, Best Affordable Choice, Predicting Consumer Choice: Substitution Effect and Income Effect.

**Output and Cost:** Concept of Short-Run and Long-Run, Average, Marginal and Total Product, Relationship Between AP and MP, Law of Diminishing Marginal Returns, Variable Cost, Fixed Cost and Total Cost, Returns to Scale, Relationship Between AC and MC.

**Perfect Competition Market:** Features of Perfect Competition Market, Marginal Analysis of a Firm, Short-Run and Long-Run Supply Curve of a Firm, Profit Outcomes in the Short-Run and Long-Run, Breakeven And Shutdown Point, Efficiency of Competition.

**Imperfect Competition Market:** Features of Monopoly, Monopolistic Competition, and Oligopoly, Price Settings Strategies of Monopoly, Price Discrimination and its Types, Monopoly's Output and Price, Dead Weight Loss.

#### Text

1. Parkin, M (2013), *Microeconomics*, 11<sup>th</sup> Edition, Pearson Education Inc., Australia.

## References

1. Cowen, T., and Tabarrok, A. (2013), *Modern Principles: Microeconomics*, Worth Publisher.
2. Case, K. E., and Fair, R. C. (2006), *Principles of Microeconomics*, Pearson Education.

### STAT LAB-108: Statistical Data Analysis I

½ Unit/2 Credit (at Least 35 Class Hours)

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks)

(Related Course - STAT-101: Introductory Statistics)

Construction of Frequency Distributions Tables with Closed and Open Class Intervals, Graphical Representation, Statistical Averages and Percentiles, Variance, Standard Deviation, Standard Error, Mean Deviation from Mean and Median, Range, Quartile Deviation, Moments, Cumulants, Sheppard's Corrections For Grouping Error, Coefficient of Measure of Skewness and Kurtosis, Box Plot and Steam and Leaf Plot, Fitting of Simple Regression Lines, Correlation Coefficient, Rank Correlation Coefficient, Contingency Table Analysis. Correlation Ratio.

Calculation of Indexes, Different Tests of Index Numbers, Construction of Cost of Living Index.

Isolation of Different Components of Time Series, Estimation of Secular Trend, Cyclical Variation, Seasonal Variation, Irregular Variation, Moving-Average Method, Weighted Moving Average Method, Linear Trend, Least Squares Method, Nonlinear Trend, Seasonal Variation, Determining Seasonal Indices, Forecasting Of Deseasonalized Data.

### STAT LAB-109: Statistical Data Analysis II

½ Unit/2 Credit (at Least 35 Class Hours)

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks for Each Group)

#### Group A (Marks: 30)

(Related Course - STAT-104: Introduction to Computer and Computer Programming)

**MS Excel:** Analyzing Data in Worksheet, Drawing Different Statistical Charts and Graphs of Statistical Data, Probability Distributions, Different Functions Related to Measures of Central Tendency, Measures of Dispersion, Correlation and Regression Analysis, Binomial Distribution, Poisson Distribution, Normal Distribution, Constructing Macro and Pivotal Table, Calculation of Probability, Matrix Operations.

**Programming Language C:** Solving Various Statistical Problems (Measures of Central Tendency, Measures of Dispersion, Correlation and Regression) Using C.

#### Group B (Marks: 20)

(Related Course – STAT-105: Algebra and Numerical Analysis)

**Using SPSS, R or Programming Language C:** Matrix Addition, Multiplication, Calculation of Determinant Value and Matrix Inversion, Newton's Forward and Backward Interpolation Formulae, Lagrange's Formula, Newton's General Interpolation Formula.

**Numerical Integration:** Using Simpson's, Weddle's, Trapezoidal and Euler's Rules, Numerical Double Integration Using Standard Software and Computer Programs.

**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 Using Standard Software and Computer Programs.

## Part II

### STAT-201: Probability Distribution

½ Unit/2 Credit (at Least 35 Class Hours)

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

**Univariate Discrete Distributions:** Rectangular, Geometric, Hypergeometric, Negative Binomial, Multinomial, Logarithmic, Beta-Binomial, Generalized Negative Binomial, Negative Hypergeometric Distribution, Power Series Distribution, Edgeworth Series, Gram Charlie's Series

**Univariate Continuous Distributions:** Uniform, Normal, Beta, Exponential, Gamma, Half Normal, Log Normal, Cauchy, Weibull, Inverted Gamma, Inverse Gaussian, Laplace, Gumbell, Maxwell, Erlang, Pareto and Other Exponential Family of Distribution, Rayleigh and Rician Distribution.

**Special Distribution:** Pearsonian Type Curves, Contagious, Truncated and Mixture Distribution of Normal, Poisson and Binomial.

**Bivariate Distribution:** Binomial, Poisson, Geometric, Normal, Gamma and Beta.

#### Texts

1. Krishnamoorthy, K. (2006): *Handbook of Statistical Distributions with Applications*, Chapman and Hall/CRC.

#### References

1. Johnson, N., Kotz, S. and Kemp, A. (2008): *Univariate Discrete Distributions*, 3<sup>rd</sup> Edition, John Wiley and Sons, New York.
2. Johnson, N. and Balakrishnan, N. (1995): *Continuous Univariate Distribution*, 2<sup>nd</sup> Edition, John Wiley and Sons, New York.
3. Devore, J. L. (2011): *Probability and Statistics for Engineering and Sciences*, 8<sup>th</sup> Edition, Duxbury Press.
4. Hogg, R. V. and Craig, A. T. (2012): *Introduction of Mathematical Statistics*, 7<sup>th</sup> Edition, Pearson Education, Asia.
5. Mood, A. M., Graybill, F. A. and Boes, D. C. (1974): *Introduction to the Theory of Statistics*, 3<sup>rd</sup> Edition, Tata McGraw-Hill, New Delhi.
6. Ross, S. M. (2014): *Introduction To Probability and Statistic for Engineers and Science*, 5<sup>th</sup> Edition John Wiley and Sons, New York
7. Evans, M., Hasting, N. and Peacock, B. (2000): *Statistical Distributions*, 3<sup>rd</sup> Edition, Wiley, New York.

### STAT-202: Sampling Distribution

1 Unit/4 Credit (at Least 50 Class Hours)

**Distributions of Functions of Random Variable:** Random Variable, Properties of Random Variable, Functions of Random Variable, Concept of Sampling Distribution, Methods of Obtaining Sampling Distribution, Variate Transformations: Cumulative Distribution Function Technique, Moment Generating Function Technique and Transformation Technique, Laplace Transformation.

**Sampling Distribution and Their Properties:** Exact Sampling Distribution Related To Normal Population, Distribution of Sample Mean, Sample Variance, Sample Covariance; Distribution of Central And Non- Central Chi Square, Student  $T$ , and Variance Ratio  $F$  Statistics and Their Distributions, Distribution of Sample Correlation and Regression Coefficients, Joint Distribution of Sample Correlation Coefficient and Covariances, Fisher's  $Z$  Distribution.

**Law of Large Number:** Theory of Large Samples, Convergence of Random Variable, Modes of Convergence, Law of Large Number (Strong Law and Weak Law), Central Limit Theorem, Standard Errors of Estimators in Large Samples (Mean, Variance, Standard Deviation, Correlation Coefficient, Regression Coefficient, Coefficient of Variation).

**Order Statistics:** Definition, Joint Distribution of  $n$  Order Statistics, Marginal Distribution of Order Statistics, Conditional Distributions of Order Statistics, Distribution of Functions 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.

#### Texts

1. Hogg, R. V. and Craig, A. T. (2012): *Introduction of Mathematical Statistics*, 7<sup>th</sup> Edition, Pearson Education, Asia.
2. Arnold, B. C., Balakrishnan, N. and Nagaraja, H. N (2008): *A First Course in Order Statistics*, SIAM.

#### References

1. Hoel, P. G. (1984): *Introduction to Mathematical Statistics*, 5<sup>th</sup> Edition, John Wiley and Sons, New York.
2. David, H. A. (1980): *Order Statistics*, 2<sup>nd</sup> Edition, John Wiley, New York.
3. Lindgreen, B. W. (1976): *Statistical Theory*, 3<sup>rd</sup> Edition, Macmillan, UK.
4. Mood, A. M., Graybill, F. A. and Boes, D. C. (1974): *Introduction to the theory of Statistics*, 3<sup>rd</sup> Edition, McGraw-Hill, USA.
5. Rao, C. R. (1962): *Advanced Statistical Methods in Biometric Research*, Wiley, USA.
6. Rohatgi, V. K. (1976): *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern, India.



## STAT-203: Regression Analysis

1 Unit/4 Credit (at Least 50 Class Hours)

**Simple Linear Model:** Linear Model, Regression Function, Simple Linear Regression, Least Square Estimators and their Properties, Precision of the Estimated Regression Model, Examining Regression Equation, Lack of Fit and Pure Error, Confidence Interval and Test of Hypothesis, Inverse Linear Regression.

**Multiple Regression Model:** Test of Linearity, Transformation of Variables, Three Variable Regression and its Parameters' Estimation, Partial and Multiple Correlation Coefficient, Correlation Ratio, Inter and Intra-Class Correlation, Confidence Interval of Correlation and Regression Coefficient, Testing of Hypothesis in Three Variable Regression, General Linear Regression Model and its Parameters Estimation, Properties of OLS Estimators, Orthogonal Columns in  $X$  – Matrix, Families of Transformations, Dummy Variables Regression, Hypothesis Testing in General Regression Model, Weighted Least Squares, Restricted Least Squares, Errors in Predictors (as Well as in Response), Inverse Regression (Multiple Predictors Case).

**Regression for Binary Data:** Logistic 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, Measures of Influences: Cook's D, DFFITS AND DFBETAS, Leverage, Measures of Model Performances.

**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 Regression:** Non-Linear Model, Estimating Parameters of Non-Linear System, Re-Parameterization of Model, Geometry of Linear Least Squares and Non-Linear Least Squares, Non-Linear Growth Models.

**Polynomial Regression:** Polynomial Model in One and Two or More Variables, Orthogonal Polynomials.

### Texts

1. Draper, N. R. and Smith, H. (1998): *Applied Regression Analysis*, 3<sup>rd</sup> Edition, John Wiley and Sons Inc, USA.
2. Montgomery, D. C. and Peek, E. (2007): *Introduction to Linear Regression Analysis*, 4<sup>th</sup> Edition, Wiley, New York.

### References

1. Chatterjee, S. and Hadi, A. S., (2012): *Regression Analysis by Example*, 5<sup>th</sup> Edition, Wiley.
2. Johnston, J. (1997): *Econometric Methods*, 4<sup>th</sup> Edition, Mcgraw-Hill, New York.
3. Koutsoyiannias, A. (2001): *Theory of Econometrics*, 2<sup>nd</sup> Edition, Macmillan, USA
4. Kutner, M. H., Nachtsheim, C. J. and Neter, J. (2004): *Applied Linear Statistical Models*, 5<sup>th</sup> Edition, Mcgraw-Hill.
5. Gujarati, D. N. (2009): *Basic Econometrics*, 5<sup>th</sup> Edition, Mcgraw-Hill

## STAT-204: Demography

½ Unit/2 Credit (at Least 35 Class Hours)

**Introduction:** Demography and Population Studies, Relationship between Demography and Other Disciplines, Glossary of Population Research Terms, Aims and Objectives of Population Studies, Important Characteristics of Demography.

**Age and Sex Composition:** Age and Sex Composition and their Importance.

**Demographic Data:** 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, Sample Surveys and their Advantages and Disadvantages.

**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.

**Fertility and Fecundity:** Detail Study of Fertility, Fecundity, Various Measures of Fertility, Important Determinants of Fertility, Estimation of Mean Age at Childbearing.

**Standardization:** 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.

**Mortality and Morbidity:** Concept of Mortality and Morbidity, Important Determinants of Mortality, Various Measures of Mortality and Morbidity, Adjusted Measures of Morbidity, IMR and its Components (Neonatal and Post-Neonatal Infant Mortality), Life Table and its uses, Current and Cohort Life Table, Construction of Life Table.

### Text

1. Shryock, H. S. (1976): *The Methods and Materials of Demography*, Academic Press, New York.

### References

1. Biswas, S. (1988): *Stochastic Process in Demography and Applications*, Wiley Eastern, New Delhi.
2. 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.
3. Everit, B. S. (2010): *The Cambridge Dictionary of Statistics in the Medical Sciences*, 4<sup>th</sup> Edition, Cambridge University Press, UK.
4. Misra, B. D. (1980): *An Introduction to the Study of Population*, South Asia, New Delhi.

5. Pressat, R. (1988): *The Dictionary of Demography*, Blackwell, UK.
6. Ramakumar, R. (1986): *Technical Demography*, Wiley Eastern, New Delhi.
7. Robert, L. B. (1997): *Introduction to the Mathematics of Demography*, 3<sup>rd</sup> Edition, Aetex Publications, Winsted, USA.
8. Spiegelman, M. (1968): *Introduction to Demography*, Harvard University Press, USA.
9. United Nations (1990): *Step by Step Guide to the Estimation of Child Mortality*, *Population Studies*, No. 107, USA.
10. 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.
11. William, B. (1975): *Methods for Estimating Fertility and Mortality from Limited and Defective Data*, Chapel Hill, University of North Carolina Press, London.
12. Bangladesh Bureau of Statistics (2012): *1981, 1991, 1993, 2001, 2011 Bangladesh Population Census Report*, Bangladesh.

## STAT-205: Quality Control and Educational Statistics

½ Unit/2 Credit (at Least 35 Class Hours)

**Basic Principles of Quality Control:** Meaning of Quality, Quality Improvement, Statistical Methods for Quality Control and Improvement.

**Methods and Philosophy of SPC:** Causes of Variation, Statistical Basis of the Control Chart: Basic Principles, Choice of Control Limits, Analysis of Patterns on Control Charts etc., Implementation and Application of SPC.

**Control Charts for Variables:** Control Charts:  $\bar{X}$ ,  $R$  and  $S$ , the Effect of Non Normality on  $\bar{X}$ ,  $R$  Charts, OC Function, the average Run Length for the  $\bar{X}$  Chart, the Shewhart Control Chart for Individual Measurements, Applications of these Charts.

**Control Charts for Attributes:** Development of Different Control Charts: for Fraction Nonconforming, for Nonconformities, the OC Function and the ASN Curve for these Charts.

Choice between Attribute and Variable Control Charts, Guidelines for Implementing Control Charts.

**Process and Measurement System Capability Analysis:** Process Capability Analysis using Six-Pack, Using Histogram, a Probability Plot, Process Capability Ratios, using Control Charts, Design of Experiments etc.

Tolerance Limits: Parametric and Nonparametric Limits.

### Other Statistical Process Monitoring and Control Techniques:

The Exponentially Weighted Moving average Control Chart, the Moving Average Control Charts.

### Acceptance Sampling:

Types, Lot Formation, Guidelines of using Acceptance Sampling.

**Single Sampling Plan:** Designing of the Plan, the OC Curve, Rectifying Inspection etc.

**Double, Multiple and Sequential Sampling Plan:** Design of the Plans, the Oc Curve, the ASN Curve etc.

**The Dodge-Romig Sampling Plans:** The AOQL Plans, LTPD Plans, Estimation of Process Average etc.

**Other Acceptance Sampling Plans:** Acceptance Sampling by Variables, Sequential Sampling by Variables, Chain Sampling etc.

**Statistical Quality Control and Six-Sigma:** Six  $\sigma$ , Process Control and its Applications; Six  $\sigma$  Quality Assurance, Quality Management System; Quality Management Tools used in Six  $\sigma$ , Six Steps to Six  $\sigma$  Control, Methods of Six  $\sigma$  Process: DMAIC (Duh-May-Ick), DMADV (Duh-Mad-Vec); Some Common Tools, Techniques and Unit of Measurements to Achieve Six  $\sigma$ : Cause and Effect Diagram Also Known as a Fishbone Diagram, Cp/Cpk (Process Capability), DFSS-Design for Six Sigma, DMAIC - Define, Measure, Analyze, Improve, Control, Control Charts, DPMO - Defects Per Million Opportunities, DOE - Design of Experiments, PDCA - Plan Do Check Act, R and R Repeatability and Reproducibility, Tolerance Design, SPC - Statistical Process Control Etc.

**The Educational Statistics:** Importance of Studying Educational Statistics, Different Scores, Scaling Individual Test Items:  $\sigma$  Scaling and  $z$  Scaling,  $T$  Scores and its Computation, Reliability and Validity of the Test Scores, Methods of Determining Reliability and Validity of a Test Score, Comparisons of Reliability and Validity, Intelligent Quotient.

### Official Statistics:

Official Statistics of Bangladesh Especially Related to Sectors of Economy and Population; Statistical Data Sources: Official and Other Sources, Critical Evaluation of Sources and their Limitations: Constraints in BBS in Respect of Governance, Data Collection and Dissemination; Problems Associated with Administrative Data, Major Obstacles/Weakness in using Administrative Data for Statistical Purpose, Recent Innovative Measures for Improvement Official Statistics.

Publications of Different *Sources of Official Data*: Bangladesh Bank, Ministry of Finance, Bangladesh Bureau of Statistics etc.

Publications of the Subsequent Sources: Board of Investment (BOI) of Bangladesh, Climate Change Cell, Export Promotion Bureau, Bangladesh Export Statistics.

Publications of Other Data Sources: Asian Development Bank (ADB), the International Food Policy Research Institute (IFPRI), the International Labour Organization (ILO), the International Monetary Fund (IMF), and the World Bank.

### Text

1. Montgomery, D. C. (2008): *Introduction to Statistical Quality Control*, 6<sup>th</sup> Edition, John Wiley and Sons, New York.

### References

1. Banks, J. (1989): *Principles of Quality Control*, John Wiley and Sons, New York.

- Burr, J. (2004): *Elementary Statistical Quality Control*, CRC Press.
- Duncan, A. J. (1970): *Quality Control and Industrial Statistics*, 3<sup>rd</sup> Edition, Richard D. Irwin, Homewood, Illinois.
- Gupta, S. C. and Kapoor, V. K. (2014), *Fundamentals of Applied Statistics*, Sultan Chand and Sons, New Delhi.
- Grant, E. L. (1996): *Statistical Quality Control*, 7<sup>th</sup> Edition, Mcgraw-Hill, New York.
- Garrett, H. E. (1958): *Statistics in Psychology and Education*, Vakits, 5<sup>th</sup> Edition, New York.
- Kendall, M. G. and Stuart, A. (1966): *The Advanced Theory of Statistics*, 1<sup>st</sup> Edition, Mcgraw-Hill, India.

## STAT-206: Macroeconomics and Economic Statistics

½ Unit/2 Credit (at Least 35 Class Hours)

**Overall Economic Situation:** Major Macroeconomic Problems – (Inflation, Unemployment and Low Growth Rate). Macroeconomic Policy and Goals. National Output Concepts, Measurement of National Output, Rates of Growth, Unemployment and Inflation.

**Aggregate Demand and Aggregate Supply Model:** Determinants of Aggregate Demand – Consumption, Savings and Investment – Aggregate Supply – Short Run and Long Run. Determination of Income in the Very Short Run, Concept of Multiplier.

**Money and Monetary Institutions:** Types and Functions of Money. Constituents of Money Supply. Role of Central Bank and Commercial Bank, Multiple Expansion of Deposits – Control of Money Supply. Demand for Money – Quantity Theory of Money.

**Role of Government and Fiscal Policy:** Objectives of Government – Objectives and Instruments of Fiscal Policy. Budget – Deficit Budget and Surplus – Financing the Deficit, Sources of Revenue, Direct and Indirect Taxes, Government Purchases and Transfer Payment.

**Working of Monetary and Fiscal Policy:** Monetary and Fiscal Policy in a Closed Economy, Open Economy – Basis for Trade Theory of Comparative Advantage – Perfect Mobility of Capital – Determination of Interest Rate – Exchange Rate Determination. Monetary and Fiscal Policy in an Open Economy. Multipliers in the Short Run and in the Long Run.

**Inflation:** Causes of Inflation, Cost Push and Demand Pull Inflation, Stagflation, Demand and Supply Side Factors of Inflation, Phenomenon of Phillips Curve.

**Economic Growth and Cycles:** Nature of Business Cycles. Sources of Growth. Benefits and Costs of Growth. Theories of Growth.

**Income Distribution:** Law of Income and Wealth Distribution, Income Inequality, Sources of Income Inequality, the Effect of Inequality on Economic Growth and Productivity, *Two Popular Income Distributions:* Pareto Distribution and Lognormal Distribution.

Justifying Suitability of the Two Distributions in the Context of Bangladesh.

**Poverty, Inequality, and Development:** Measuring Inequality and Poverty - Size Distribution, Lorenz Curves, Gini Coefficient, Poverty Gap, Foster-Greer-Thorbecke Index, Human Poverty Index, Dualistic Development, Growth and Inequality, Growth and Poverty, Economic Characteristics of Poverty Groups, Ahliwalia-Chenery Welfare Index.

### Text

- Mankiw, N. G. (2014), *Principles of Macroeconomics*, Cengage Learning.

### References

- M. Parkin (2015): *Macroeconomics*, 12<sup>th</sup> Edition, Pearson.
- J. E. Stiglitz (1997): *Principles of Macroeconomics*, 2<sup>nd</sup> Edition, Norton and Company, Inc.
- N. G. Mankiw (1997): *Macroeconomics*, 3<sup>rd</sup> Edition, Worth Publishers.
- P. A. Samuelson and W. D. Nordhaus: *Economics*, 17<sup>th</sup> Edition.
- R. Dornbusch, S. Fischer and R. Startz (2002): *Macroeconomics*, 8<sup>th</sup> Edition, Tata Mcgraw Hill.
- R. G. Lipsey and K. A. Chrystal (2004): *Economics*, 10<sup>th</sup> Edition (First Indian Edition), Oxford University Press.
- Taslim and Chowdhury (1995): *Macroeconomic Analysis*, Prentice Hall.
- W. H. Branson (1989): *Macroeconomic Theory and Policy*, 3<sup>rd</sup> Edition.
- Lora D. Dewiche and Susan J. Slaughter (2003): *The Little SAS Book, a Primer*, 3<sup>rd</sup> Edition. SAS Publication

## STAT-207: Mathematical Analysis and Differential Equations

1 Unit/4 Credit (at Least 50 Class Hours)

Complex Number, Functions, Limit, and Continuity of Complex Variable, Differentiability, Analytic Function, Cauchy Riemann Equations, Complex Integration and Cauchy's Theorem, Cauchy's Integral Formula, Infinite Series, Taylor's and Laurentz Series, Singularities, Residue Theorem, Calculus of Residuals, Leibnitz's Rule, Dirichlet Integral, Taylor and Maclorin Series, Evaluation of Real Improper Integrals (Contour Integration).

Origin of Different Differential Equations, General Principle, Elementary Standard Types, Existence Theorem, Linear Equation with Constant Coefficients, Euler's Method, Equation of First Order and First Degree, Separable Equations, Exponential Growth and Decay, and Logistic Equation, Partial Differential Equations of First and Second Order, Solution to Differential Equations, Laplace Transform, Solution in Series, Special Functions, Legendre, Bessel and Hypergeometric Functions, Fourier Transformation.

### Text

- Rudin, W. (1976): *Principles of Mathematical Analysis*, 3<sup>rd</sup> Edition, Mcgraw-Hill, USA.
- Zill, D. G. (2013): *A First Course in Differential Equations with Modeling Applications*, 10<sup>th</sup> Edition, Cengage Learning.

### References

- Chiang, A. and Wainwright, Kevin (2005): *Fundamental Methods of Mathematical Economics*, 4<sup>th</sup> Edition, Mcgraw Hill.
- Apostel, T. M. (1992): *Mathematical Analysis*, 11<sup>th</sup> Edition, Norosa, India.
- Ayres, F. Jr. (1972): *Theory and Problems of Differential Equations*, *Schaum's Outline Series*, Mcgraw-Hill, New York.
- Gupta, S. L. and Rani, N. (1993): *Fundamental Real Analysis*, 3<sup>rd</sup> Rev. Edition, Vikas, India.

5. James Stewart (1998): *Calculus, Concept and Contests, Single Variable*, GWO Brooks/Cole Publishing Company.
6. Spiegel, M. R. (1964): *Theory and Problem of Complex Variable*, Schaum's Outline Service, Mcgr-Hill Book Company.

## STAT-208: Statistical Simulation and Data Processing

1 Unit/4 Credit (at Least 50 Class Hours)

### Simulation

**Overview:** Meaning, Motivational Example, Simulation Process, Verification, Validation, Synchronous and Asynchronous Discrete Event Simulation, Continuous Event Simulation, Hybrid Event Simulation, Monte Carlo: Hit or Miss Monte Carlo Method, Sample-Mean Monte Carlo Method.

**Variance Reduction Technique:** Stratified Sampling, Conditional Monte Carlo, Jackknifing, Antithetic Variates.

**Generating Uniform Random Variable:** Classes of Generators – Random Devices, Tables, Midsquare Method, Fibonacci and Additive Congruential Generators, Linear Congruential Generators, Linear Recursion Mod 2 Generator, Combinations of Generators, Choosing Good Generator Based on Theoretical Considerations, Serial Correlation, Cycle of Length, Spectral Test.

**Empirical Testing Of Uniform Random Number Generators:** Chi-Square Test, Kolmogorov-Smirnov Test, Gap Test, Run Test, Poker Test, Test of Autocorrelation, Maximum Test.

**Generating Non-Uniform Random Variables:** Alias Method, Inverse Transformation Method, Acceptance-Rejection Method, Polar Method, Method of Generating Random Numbers from Normal, Exponential, Gamma, Beta,  $\chi^2$ ,  $t$ ,  $F$ , Cauchy, Binomial, Poisson, Geometric, Negative Binomial Distributions.

**Statistical Analysis of Simulated Data:** Checking Properties of BLUE, Estimating Parameters of Linear Regression and Non-Linear Regression Model, Interval Estimates of Population Mean.

### 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.

### SAS

**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.

### Texts

1. Bartley, P., Fox, B. L. and Schrage, L. E. (1987): *A Guide to Simulation*, 2<sup>nd</sup> Edition, Springer-Verlag, New York.
2. Cody, R. P. and Smith, J. K. (2005): *Applied Statistics and the SAS Programming Language*, 5<sup>th</sup> Edition, Pearson.
3. Norusis, M. J. (1988): *A Guide SPSS/PC for Data Analysis*, SPSS Inc., USA.

### References

1. Afifi, A. A. and Azen, S. P. (1979): *Statistical Analysis: A Computer Oriented Approach*, 2<sup>nd</sup> Edition, Academic Press, New York.
2. Law, M. A. (2006): *Simulation Modeling and Analysis*, 4<sup>rd</sup> Edition, Mcgraw-Hill.
3. Ross, B. M. (2012): *Simulation*, 5<sup>th</sup> Edition, Academic Press, USA.
4. Rubinstein, R. Y. and Kroese, D. P. (2007): *Simulation and the Monte Carlo Method*, 2<sup>nd</sup> Edition, John Wiley and Sons, New York.

### **STAT LAB-209: Statistical Data Analysis III**

**½ Unit/2 Credit (at Least 35 Class Hours)**

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks for Each Group)

#### **Group A (Marks: 30)**

(Related Course - STAT-203: Regression Analysis)

Fitting of Simple Regression, Correlation Coefficient, Determination of Intra-Class and Inter-Class, Fitting of Multiple Regression Model, Partial Regression Model, Multiple and Partial Correlation Coefficients, Test of Significance of Simple, Multiple, Partial Correlation and Regression Coefficient, Tests of Influential and Outlier Observations by Different Methods, Fitting of Ridge Regression. Fitting of Polynomial Regression and Orthogonal Polynomial Model, Durbin Watson Test for Serial Correlation.

#### **Group B (Marks: 20)**

(Related Course - STAT-204: Demography)

Calculation of Rates and Ratios, Standardization of Rates, Meyer's Index, Whipple's Index, United Nations Index, Estimation of Under and Over Count, Intrinsic Rates, Mean and Median Age at Marriage, Growth Rates, Migration, Child Mortality, Adult Mortality, Coale's Indices, Construction of Nuptiality Tables, Life Tables.

### **STAT LAB-210: Statistical Data Analysis IV**

**½ Unit/2 Credit (at Least 35 Class Hours)**

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks for Each Group)

#### **Group A (Marks: 10)**

(Related Course - STAT-205: Quality Control and Educational Statistics)

Different Types of Control Charts, Determination of Sampling Plan in Different Situations, OC Curve for Different Sampling Plans, Average Sample Number and Average Outgoing Quality Level for Different Sampling Plans, Fitting of Curve for Different Sampling Plans. Calculation of Different Scores and their Standardization, Calculation of IQ.

#### **Group B (Marks: 40)**

(Related Course - STAT-208: Data Processing and Statistical Simulation)

**Simulation:** Generating Random Number from Uniform, Binomial, Poisson, Normal, Exponential, and Gamma and Weibull Distribution by Different Monte-Carlo Methods and Using Standard Softwares 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 Through SPSS and SAS:** Solving Different Statistical Problems by SPSS and SAS (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.

## Part III

### STAT-301: Statistical Inference I

1 Unit/4 Credit (at Least 50 Class Hours)

#### Group A: Parametric Inference

**Point Estimation:** Point Estimation And Properties of Good Estimator, Method of Finding Estimators, Maximum Likelihood Estimation, Method of Moments, Method of Minimum  $\chi^2$ , Method of Least Squares, Method of Minimum Distance, Properties of Point Estimator: Mean Squared Error, Fisher's Consistency, 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:** Sufficient Statistic, Joint Sufficient Statistic, Completeness and Joint Completeness, Rao-Blackwell Theorem, Lehman-Scheffe Theorem, Ancillary Statistics, Minimal Sufficient Statistics, Sufficiency of General Order Statistics. Exponential Family.

**Interval Estimation:** Fundamental Notions of Confidence Interval Estimation, Different Methods of Interval Estimation, Properties and Construction of Confidence Interval by Different Methods. Confidence Interval for Mean and Variance, Length of Confidence Interval, Shortest Length Confidence Interval, Simultaneous Confidence Interval for Mean and Variance.

#### Test of Hypothesis

Fundamental Notions of Hypothesis Testing, Basic Concepts and Ideas of Test of Significance in Small and Large Samples, Type I and Type II Error, Level of Significance, P-Value, Power of the Test, Neyman-Pearson Lemma, Composite Hypothesis, Simple Likelihood Ratio Test.

Tests Based on  $Z$ ,  $t$ ,  $F$  and  $\chi^2$  Statistics, Fisher's Exact Test, Analysis and Test Based on  $r \times c$  Contingency Table.

#### Group B: Non-Parametric Inference

**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 Control Median Test, 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.

Tolerance Limits for Distributions, Coverage, Confidence Interval Estimates of Population Quintiles.

#### Texts

1. Hogg, R. H., Mckean, J. and Craig, A. T. (2014): *Introduction to Mathematical Statistics*, 7<sup>th</sup> Edition, Pearson Education Ltd.
2. Mood, A. M., Graybill, F. A. and Bose, D. C. (1974): *Introduction to the Theory of Statistics*, 3<sup>rd</sup> Edition, Mcgraw-Hill, New York.
3. Gibbons, J. D. and Chakraborti, S. (2011): *Nonparametric Statistical Inference*. 5<sup>th</sup> Edition, Chapman and Hall/CRC.

#### References

1. Devore, J. L. (2010): *Probability and Statistics for Engineering and Sciences*, 8<sup>th</sup> Edition, Cengage Learning.
2. Rohatgi, V. K. and Saleh, A. K. M. E. (2015): *An Introduction to Probability Theory and Mathematical Statistics*, John Wiley and Sons, Inc, New York.
3. Stuart, A., Ord, K. J. and Arnold, S. (1999): *Kendall's Advanced Theory of Statistics*, 6<sup>th</sup> Edition, Vol. 2A, Arnold Publishers, London/Oxford University Press, USA.
4. Conover, W. J. (1999): *Practical Nonparametric Statistics*, 3<sup>rd</sup> Edition, John Wiley and Sons Inc., New York.
5. Rohatgi V. K. and Saleh, A. K. M. E. (2001): *An Introduction to Probability and Statistics*, 2<sup>nd</sup> Edition, John Wiley and Sons Inc., New York.

## STAT-302 Analysis of Variance

½ Unit/2 Credit (at Least 35 Class Hours)

Basic Concept of Experimental Design and Non-Experimental Design, Basic Concept of Analysis of Variance, Linear Models, Analysis of Variance in One-Way, Two-Way and Three-Way Classification with Equal Number of Observations Per Cell, Analysis of Variance with Fixed Effects, Mixed Effects and Random Effects Model.

Variance Component Analysis, Variance Component Analysis in One-Way, Two-Way and Three-Way Classified Data.

Nested Design, the Two-Stage Nested Designs, Statistical Analysis Variance Components, Analysis of Three-Stage Nested Design.

Covariance Analysis, Covariance Analysis with One Concomitant Variable, Analysis of Covariance in One-Way and Two-Way Classified Data with One Concomitant Variable.

### Texts

1. Montgomery, D. C. (2012): *Design and Analysis of Experiments*, 8<sup>th</sup> Edition, Wiley, USA.
2. Cochran, W. G. and Cox, G. M. (1992): *Experimental Designs*, 2<sup>nd</sup> Edition, Wiley Library Edition, John Wiley and Sons.

### References

1. Das, M. N. and Giri, N. C. (2003): *Design and Analysis of Experiments*, 2<sup>nd</sup> Edition, New Age International (P) Ltd., India.
2. Federer, W. T. (1967): *Experimental Design: Theory and Application*, Oxford and IBH, New Delhi.
3. Searle, S. R. (1971): *Linear Models*, John Wiley and Sons, New York.

## STAT-303 Sampling Techniques I

½ Unit/2 Credit (at Least 35 Class Hours)

**Concept of Sampling:** Meaning of Sampling, Importance of Sampling, Data Collection Method, Census and Survey, uses of Sample Survey, Principle Steps in Sample Survey, Advantage of Sampling, and Limitation of Sampling.

**Probability Sampling:** Simple Random Sampling with Replacement and Without Replacement, Stratified Sampling, Systematic Sampling, Relative Precision and Comparative Analysis, Cluster Sampling with Equal Size, Relative Precision of Different Sampling Scheme.

**Estimation using Auxiliary Variables:** Ratio, Regression and their Differences, Method of Estimation and their Comparative Analysis.

**Non Probability Sampling:** Convenience Sampling, Accidental Sampling, Purposive Sampling, Judgment Sampling, Quota Sampling, Snowballs Sampling, Area Sampling.

**Errors in Survey:** Introduction, Sampling Error, Non Sampling Error, Non Response Error, Measurement Error, Processing Error, 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, Observational Errors.

### Texts

1. Cochran, W. G. (2002): *Sampling Techniques*, 4<sup>th</sup> Edition, Wiley Eastern, New Delhi.
2. Thompson, S. K. (2012): *Sampling*, 3<sup>rd</sup> Edition, John Wiley and Sons Inc., New York.

### References

1. Lohr, S. L. (2010): *Sampling: Design and Analysis*, 2<sup>nd</sup> Edition, Brooks/Cole, Cengage Learning.
2. Murthy, M. N. (1977): *Sampling Methods*, 2<sup>nd</sup> Edition, Statistical Publishing Society, Calcutta.
3. Raj, D. and Chandhok, P. (1998): *Sample Survey Theory*, Narosa Publishing House, New Delhi.
4. Tryfos, P. (1996): *Sampling Methods for Applied Research*, John Wiley and Sons, New York.

## STAT-304: Operations Research

½ Unit/2 Credit (At Least 35 Class Hours)

**Basic Concept of Operation Research:** 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:** Introduction, Statement of the General Linear Programming Problem, Mathematical Formulation of Linear Programming 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, Transportation Problem.

**Game Theory:** Introduction, Properties Assumptions of Two Persons Zero Sum Game, Maximum Minimum Principle, Pure and Mixed Strategy Games, Two Person Zero Sum and its Relation with Linear Programming and Non-Zero Sum Games, Solution of Game by Graphical Methods, Simplex Method, Approximate Solution of Game by Brown's Algorithm.

**Network Models:** Scope and Definition of Network Models, Minimal Spanning Tree Algorithm, Shortest-Root Problem, Maximal Flow Model, CPM and PERT.

**Inventory Models:** Deterministic and Probabilistic Inventory Models, Role of Demand in the Inventory Models, Static and Pynamic, Economic-Order-Quality (EOQ), Single Period Models, Multi Period Models.

**Decision Analysis:** Decision Making Under Certainty-Analytic-Hierarchy Process (AHP), Decision Making Under Risk, Decision under Uncertainty.

#### Text

1. Taha, H. A. (2011): *Operations Research: An Introduction*, 9<sup>th</sup> Edition, Prentice-Hall: New Delhi.

#### References

1. Gass, S. I. (1985): *Linear Programming Methods and Applications*, 5<sup>th</sup> Edition, Mcgraw-Hill Ltd., New York.
2. Hadley, G. (1994): *Linear Programming*, Narosa Publishing House, New Delhi.
3. Karak, P. M. (1991): *Linear Programming and Theory of Games*, Chhaya Prakashani, India.
4. Saaty, T. L. (1959): *Mathematical Methods of Operations Research*, Mcgraw-Hill, New York.
5. Sasieni, M. and Yaspan, A. (1967): *Operations Research- Methods and Problems*, Wiley, New York.

#### STAT-305: Research Methodology

½ Unit/2 Credit (at Least 35 Class Hours)

**Basic Concepts of Research Methodology:** Meaning of Research, Objectives, Research Method and Methodology, Concepts of Theory, Proposition, Concept and Hypothesis.

**Research Process:** Concepts of Decision Making: Certainty, Uncertainty, Ambiguity, Types of Research: Exploratory, Descriptive and Causal Research, Stages in the Research Process, Research Project versus Research Program.

**Problem Definition and Research Proposal:** The Nature of the Problem, Importance of Problem Definition, Process of Problem Definition, Purpose of Proposal, Types of Research Proposal, Structuring Research Proposal, Evaluation of Research Proposal.

**Research Design:** Concepts of Research Design, Selection of Appropriate Research Design, Evaluation of Research Design, Types of Research Design: Non-Experimental: Exploratory, Descriptive and Causal Research Designs, Experimental: Pre-Experimental, True-Experimental and Quasi-Experimental Research Designs.

**Sampling Design:** Types of Data, Review of Probability and Non Probability Sampling, Technique to Collect Data.

**Attitude Measurement:** Components of Attitude, Elements of Measuring Attitude, Attitude as a Hypothetical Construct, Techniques for Measuring Attitude, Scaling Techniques of Attitude; Comparative Scales and Non-Comparative Scales. *Attitude Rating Scale:* Simple Attitude Scale, Category Scale, Summated Ratings Methods - The Likert Scale, Semantic Differential Scale, Numerical Scale, Constant Sum Scale, Stapel, Continuous Rating/Graphic Rating Scale, Behavioral Differential, Paired Comparison Scaling.

**Measurement and Scaling Concept:** Concept of 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.

**Data Management and Analysis:** Stages of Data Preparation Process, Preliminary Plan of Data Analysis, Questionnaire Checking, Editing, Coding, Re-Coding, Data Cleaning, Statistically Adjusting Data, all Statistical Techniques, Including Modeling and Inference.

**Report Preparation and Presentation:** Literature Review, Report Writing, Oral Presentation, Research Follow-Up, Reference Writing.

#### Texts

1. Zikmund, W. G., Babin, B. J., Carr, J. C. and Griffin, M. (2013): *Business Research Methods*, 9<sup>th</sup> Edition, Cengage Learning.

#### References

1. Zikmaund, W. G. (2002): *Business Research Methods*, 7<sup>th</sup> Edition, Cengage Learning.
2. Malhotra, N. K. (2006): *Marketing Research*, 4<sup>th</sup> Edition, Pearson Education, Singapore.
3. Babbie, E. (2013): *The Practice of Social Research*, 13<sup>th</sup> Edition, Cengage Learning.
4. Churchill, G. A. and Nielsen, A. C. (2010): *Marketing Research-Methodological Foundations*, 10<sup>th</sup> Edition, Cengage Learning.
5. Cooper, D. R. and Schindler, P. S. (2014): *Business Research Methods*, 12<sup>th</sup> Edition, Irwin/Mcgraw-Hill Company, New York.
6. Dooley, D. (2001): *Social Research Methods*, 4<sup>th</sup> Edition, Prentice Hall, India.
7. Trochim, W. and Donnelly, J. P. (2007): *The Research Methods Knowledge Base*, 3<sup>rd</sup> Edition, Cengage Learning.

#### STAT-306: Econometrics

1 Unit/4 Credit (at Least 50 Class Hours)

**Basic Concept of Econometrics:** Meaning, Methodology of Econometrics, Types of Econometrics, Nature and Source of Data for Econometric Analysis, Role of Computer in Econometric Analysis, Meaning of Population Regression Function (PRF) and Sample Regression Function (SRF), Stochastic Specification of PRF, Different Functional form of PRF and Transformation of PRF to Linear form.

Detail Study of Problem of Estimation and Inference in Multiple Linear Regression Models, Examination of Linear Regression Results for Fitted Line and 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  $\rho$ , Cochrane - Orcutt Iterative, Durbin's Two Step and EGLS Methods of Estimating  $\rho$ , Concept of Autoregressive Conditional Heteroscedasticity (ARCH) Model, Generalized ARCH (GARCH) Model.

Monte-Carlo Experiment: Consequence of Autocorrelation.

**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.

**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.

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.

**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.

#### Texts

1. Gujarati, D. N. and Poter, D. (2008): *Basic Econometrics*, 5<sup>th</sup> Edition, McGraw-Hill, New York.
2. Wooldridge, J. M. (2016), *Introductory Econometrics: A Modern Approach*, 6<sup>th</sup> Edition, Cengage Learning, South-Western.

#### References

1. Judge, G. G. Hill, R. C., Griffiths, W. E., Lütkepohl, H. and Lee, T. C. (1988): *Introduction to the Theory and Practice Of Econometrics*, 2<sup>nd</sup> Edition, John Wiley and Sons, New York.
2. Cameron, A. C. and Trivedi, P.K. (2005): *Microeconometrics- Methods and Application*, Cambridge University Press, UK
3. Johnston, J. and Dinardo, J. (1997): *Econometric Methods*, 4<sup>th</sup> Edition, McGraw-Hill, New York.

### STAT-307: Time Series Analysis

**1 Unit/4 Credit (at Least 50 Class 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.

**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, Identification 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, Cointegration 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.

#### Text

1. Brockwell, P. J. and Davis, R. A. (2002): *Introduction to Time Series and Forecasting*, 2<sup>nd</sup> Edition, Springer, New York.

#### References

1. Montgomery, D. C., Jennings, C. L. and Kulahci (2008): *Introduction to Time Series Analysis and Forecasting*, John Wiley and Sons, New Jersey.
2. Diebold, F. X. (2012): *Elements of Forecasting*, 4<sup>th</sup> Edition, Cengage Learning.
3. Shumway, R. H. and Stoffer, D. S. (2011): *Time Series Analysis and its Applications: with R Examples*, 3<sup>rd</sup> Edition, Springer.
4. Hamilton, J. D. (1994): *Time Series Analysis*, Princeton University Press, New Jersey.
5. Harris, R. and Robert, S. (2003): *Applied Time Series: Modeling and Forecasting*, Replika Press Pvt. Ltd., India.
6. Makridakis, S., Wheelwright, S. C. and Hyndman, R. J. (1998): *Forecasting Methods and Applications*, 3<sup>rd</sup> Edition, John Wiley and Sons, New York.

### STAT-308: Actuarial Statistics

½ Unit/2 Credit (at Least 35 Class Hours)

**Basic Concept:** Definition of Actuarial Science, its Relationship with Life Insurance, Important uses of Actuarial Statistics Especially in Context of Bangladesh.

**Interest:** Theory of Rates of Interest and Discount Including Theoretical Continuous Case of Forces of Interest and Discount,

**Amortization and Sinking Funds, and Bonds:** Amortization and Amortization Schedule, Sinking Funds Yield Rates, Annuities and Sinking Funds Including Continuous Case, Practical and Theoretical Applications Primarily to Mortgages and Bonds, Yield Rates.

**Annuities:** Meaning, Perpetuities, Continuous and Varying Annuities.

**Life Annuity and Insurance:** 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.

#### Text

1. Parmenter, M. M. (1999): *Theory of Interest and Life Contingencies with Pension Application*, 3<sup>rd</sup> Edition, ACTEX Publication, Winsted, CT, USA.

#### References

1. Ayres, F. Jr., (1963): *Theory and Problems of Mathematics of Finance*, Schaum's Publishing Co., New York.
2. Batten, R. W. (1978): *Mortality Table Construction*, Prentice Hall, New Jersey.
3. Bowers, N. L., Gerber, H. V., Hickman, J. C., Jones, D.A. and Nesbitt, C. J. (1978): *Actuarial Mathematics*, 2<sup>nd</sup> Edition, Society of Actuaries, Chicago.
4. Jordan, C. W. (1952): *Society of Actuaries' Life Contingencies*, Chicago.
5. Kellison, S. G. (2009): *Theory of Interest*, 3<sup>rd</sup> Edition, Mcgraw-Hill/Irwin.

### STAT-309: Environmental Statistics

½ Unit/2 Credit (at Least 35 Class Hours)

**Basic Idea on Environment:** Environment, Concepts of Environment, Basics of Ecology and Ecosystem, Biodiversity, Human Impact on Ecology and Biodiversity, Environment and Sustainable Development, Indispensability, and Inseparability of Sustainable Development, Theory and Practices of Sustainable Development, Greenhouse Gases and Impact of Green House Gases, Ozone Layer.

**Health Environment:** Sources of Health Risk in Air, Water, Food, and Wastes, Climate Change and Environmental Health, Arsenic Instigation in Drinking Water.

**Environmental Monitoring:** Network Sampling, Composite Sampling, Ranked-Set Sampling, Delectability, Constant Dilectability Over Region, Estimating Delectability, Effect of Estimated Delectability, Detetectability with Simple Random Sampling.

**Environmental Pollutants:** Environmental Pollutants, Impacts of Pollutants on Environment, Sources of Environmental Pollutants, Decomposition of Pollutants, Types of Environmental Pollution.

**Diffusion and Dispersion of Pollutants:** Concept of Diffusion and Dispersion of Pollutants, Distribution of Pollutants with Respect to Space and Time by Wedge 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.

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

#### Texts

1. Thompson, S. K. (2012): *Sampling*, 3<sup>rd</sup> Edition, John Wiley and Sons Inc., New York.
2. Wayne, R. Ott. (1995): *Environmental Statistics and Data Analysis*, Lewis Publishers, England.

#### References

1. Barnett, V. and Turkman, K. F. (1993): *Statistics for the Environment*, John Wiley and Sons, Chichester.
2. Hill, M. K. (2012): *Understanding Environmental Pollutions*, 3<sup>rd</sup> Edition, Cambridge University Press, London.
3. Barnett, V. (2004): *Environmental Statistics: Methods and Applications*, John Wiley and Sons, New York.

### STAT-310: Data Processing with Statistical Software

½ Unit/2 Credit (at Least 35 Class Hours)

**STATA:** Introduction to STATA, Different Windows of STATA, Converting Data by Stat Transfer, Importing and Exporting Data, Data Entry, Data Cleaning, Data Management: Imputing, Editing Data, Generating and Changing Variables, Saving and Reusing Data, Data Reorganization, Data Merging and Appending; Basic STATA Commands, Creating do File, STATA Commands for Different Probability Distributions, Vector and Matrix Operations: Transpose, Addition, Subtraction, Multiplication and Inversion, Solution of Simultaneous Equations.

**Minitab:** Introduction to Minitab, Accessing Minitab, Minitab Worksheet, Menu and Session Commands, Entering Data from Keyboard, Doing Arithmetics, Interoperability in Minitab, Transferring Data from MS Excel to Minitab, Exporting Analysis Data From Minitab to Word and PPT, Exporting Data from Session Window to Word and PPT, Generate Different Charts in Minitab, Descriptive Measures, Basic Probability Calculation, Finding Probabilities by Different Probability Distributions, Confidence Interval Estimation, Parametric and Non-Parametric Test of Hypothesis, Correlation and Regression, Design of Experiments and Analysis of Variance, Solving Different Statistical Problems by Minitab.

**R:** History of R, R versus STATA, Downloading and Installing R, Simple R Session with some Basic Commands, Case-Sensitivity, Recall and Correction of Previous Commands, Assignments and Expressions, Simple Manipulations of Numbers, Getting Help on R, Data Objects and Data Structure, Importing Data, Data Manipulation, Graphics, Obtaining Densities, Cumulative Probabilities, Quantiles and Random Samples from Different Probability Distributions, Writing Functions, Conditional Execution with If Statement, Repetitive Execution with for, Repeat and while Statements.

**Applications of STATA, Minitab and R:** Basic Statistical Techniques, Graphs, Correlation and Regression, Estimation of Parameters of Multiple Regression Model, Inference in Multiple Regression, Partial Correlation, Multiple Correlation and Related Tests, Model Selection, Fitting Polynomial Regression, Examination of Residuals, Outliers, Influential Points, Logistic Regression.

#### Texts

1. Statacorp L P (2013): *Stata Base Reference Manuals*, Stata Press Publication, Texas.
2. J. Mckenzie, R. Schaefer, E. Farber, (1994), *The Student Edition of Minitab for Windows*, Addison-Wesley.
3. Dalgaard, P. (2008): *Introductory Statistics with R*, 2<sup>nd</sup> Edition, Springer.
4. Everitt, B. and Hothorn, T. (2010): *A Handbook of Statistical Analysis Using R*, 2<sup>nd</sup> Edition, Chapman & Hall.

#### References

1. Chambers, J.M. (2008): *Software for Data Analysis: Programming With R*, Springer.
2. Venables, W. N. and D, M. Smith (2009): *An Introduction to R*, 2<sup>nd</sup> Edition, Network Theory Limited.
3. Rehman M. Khan, (2013), *Problem Solving and Data Analysis using Minitab: A Clear and Easy Guide to Six Sigma Methodology*, Wiley.
4. Lohler, U and Kreuter, F. (2012): *Data Analysis using STATA*, 3<sup>rd</sup> Edition, Stata Press
5. Acock, A. C. (2014): *A Gentle Introduction to STATA*, 4<sup>th</sup> Edition, Stata Press
6. Hamilton, L.C (2013): *Statistics with STATA-Version 12*, 8<sup>th</sup> Edition, Cengage.

### STAT LAB-311: Statistical Data Analysis V

1 Unit/4 Credit (at Least 50 Class Hours)

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks for Each Group)

#### Group A (Marks: 40)

(Related Course - STAT-301: Statistical Inference I)

Drawing Sample from Parent Population: Binomial, Poisson, Geometric, Hypergeometric, Normal, Cauchy, Gamma, Beta, Incomplete Gamma and Beta.

Estimation of Location and Scale Parameter of the Sample Drawn from the above Distributions, Maximum Likelihood Estimator, Method of Moments Estimator, Method of Least Squares Estimators.

Determination of Confidence Interval for Mean, Difference of Means, Proportion, Difference of Proportions, Correlation Coefficient, Regression Coefficient, Fitting of Different Distributions, Different Tests for Mean, Difference of Means, Equality of Several Means, Proportion, Difference of Proportion, Equality Of Several Proportions, Variances, Equality of Two and Several Variances, Equality of Several Correlation Coefficients, Regression Coefficients Based on Normal,  $t$ ,  $\chi^2$  and  $F$ , Power Curves of Different Tests.

Test of Randomness (One-Sample, Two-Sample); Wilcoxon Signed-Rank Test, Mann-Whitney U-Test, Median Tests (Two or More Samples), Kolmogorov-Smirnov Tests, Different Location and Scale Problem Tests, Kruskal-Wallis Test, Different Tests of Measures of Association.

**Group B (Marks: 30)**

(Related Course - STAT-302: Analysis of Variance)

Analysis of Variance in One-Way, Two-Way and Three-Way Classifications with Equal Number of Observations Per Cell Using Fixed Effect Model and Random Effect Model, Covariance Analysis in CRD, RBD And LSD with One Concomitant Variable, Analysis of Data in Nested Classification.

**Group C (Marks: 30)**

(Related Course - STAT-303: Sampling Techniques I)

Drawing Samples by Simple Random Sampling, Stratified 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.

**STAT LAB-312: Statistical Data Analysis VI**

**½ Unit/2 Credit (at Least 35 Class Hours)**

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks for Each Group)

**Group A (Marks: 20)**

(Related Course - STAT-304: Operations Research)

Solution of Linear Programming Problem by Geometric and Simplex Method, Transportation Problem, Game Problem: two Person Zero Sum Games, Optimization of Cost and Profits, Real Life Problem Related to Network Model and Inventory Model.

**Group B (Marks: 30)**

(Related Course - STAT-306: Econometrics)

Estimation of Parameters in Presence of Errors in Variables, 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, Input Output Analysis.

**STAT LAB-313: Statistical Data Analysis VII**

**½ Unit/2 Credit (at Least 35 - 40 Class Hours)**

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks for Each Group)

**Group A (Marks: 30)**

(Related Course - STAT-307: Time Series Analysis)

Reading and Managing Time Series Data, Construction of Time Series Plot, Decomposition, Forecasting by Exponential Smoothing, Double Exponential Smoothing and Holt-Winter Methods, Evaluation of ACVF and ACF, Checking Stationarity by Different Techniques including Examination of ACVF and ACF, DF, ADF, Phillips-Perron Tests for Unit Root and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Test for Trend Stationarity, Estimation of AR, MA, ARMA and ARIMA Models and Forecasting, Analyzing Goodness of Fit of the Models and Identify the Best Model, Simulate the Models AR, MA, ARMA and ARIMA and Hence Estimate the Parameters and Make Forecasts, Estimating and Forecasting by VAR Model.

**Group B (Marks: 20)**

(Related Course - STAT-309: Data Processing with Statistical Software)

Data Management, Univariate and Bivariate Tables, Descriptive Statistics, Graphs with Appropriate Title and Other Parameters, Performing Different Statistical Tests, Correlation, Simple and Multiple Regression, Polynomial Regression, Logistic Regression, Regression Post Estimation, Examination of Residuals, Outliers, Influential Points, Matrix and Vector Operations, PDF, CDF, Quantiles and Random Number Generations, Writing Functions, Looping.

## Part IV

### STAT-401: Statistical Inference II

**1 Unit/4 Credit (at Least 50 Class Hours)**

#### **Group A: Estimation**

Median and Modal Unbiased Estimator, Simultaneous Estimation of Several Parameters, Vectors of Parameters, Ellipsoid of Concentration, Wilk's Generalized Variance, Jackknife and Bootstrapping Techniques, Chapman-Robinsons-Keiffer Lower Bound, Generalized Rao-Cramer Lower Bound, Bhattacharya's System of Lower Bound, Efficiency, Asymptotic Efficiency, Best CUAN Estimator, Optimum Properties of ML Estimation, MLE in Truncated and Censored Distributions, General Set Up in Estimation, Location, Invariance, Pitman Estimator for Location and Scale.

Bayesian Estimation: Loss Function, Risk Function, Admissible Estimator, Minimax Estimator, Bayes Factor, Conjugate Prior, Noninformative Prior, Jeffrey's Non Informative Prior, Maximum Entropy Priors, Squared Error Loss Function, Linex Loss Function, Bilinear Loss Function, Modified Linex Loss, Entropy Loss, Intrinsic Loss, Balanced Loss, Capture-Recapture Problem, Linear Bayes Estimator, Equivariance, Principle of Equivariance, Minimum Risk Equivariant Estimator (MRE), Location Scale Families, Some Methods Of Estimation in Large Samples, Confidence Belt, Theory of Confidence Sets, Shortest Set of Confidence Intervals, Relationship Between Confidence Estimation and Hypothesis Testing, Unbiased Confidence Intervals, Fiducial Interval, Bayesian Interval, Fishers-Behreu Problem.

#### **Group B: Test of Hypothesis**

Most Powerful Test, Uniformly Most Powerful Test, Uniformly Most Powerful Unbiased Test, Locally Uniformly Most Powerful Test, Locally Uniformly Most Powerful Unbiased Test, Optimal Tests in Different Situations, Randomized Tests, Consistent Tests, Unbiased Tests, Similar Region, Fisher-Behren Problem, Generalized Likelihood Ratio Tests, Monotone Likelihood Ratio, Test of Homogeneity in Parallel Samples, Concepts of Relative Sample Sizes, LM Test, Wald Test.

Prior and Posterior Odds, Bayes Factor for Simple vs Simple Hypothesis, Bayes Factor for Composite vs Composite Hypothesis.

Sequential Analysis, SPRT, Efficiency of SPRT, Fundamental Identity of Sequential Analysis, O.C. Function of Sequential Plan, ASN Function.

Bayesian Test of Hypothesis, Test of Influential Variables in Predictive Approach, Bayesian Approach to Contingency Tables. Concepts of Decision Theory.

#### **Texts**

1. Cassela, G. and Berger, R. L. (2008): *Statistical Inference*, 2<sup>nd</sup> Edition, Wadsworth Publishing Co., California.
2. Gelman, A., Carlin, J. B., Stern, H. S. and Rubin, D. B. (2013): *Bayesian Data Analysis*, 3<sup>rd</sup> Edition, CRC Press, New York.
3. Hogg, R. H., Mckean, J. W. and Craig, A. T. (2012): *Introduction to Mathematical Statistics*, 7<sup>th</sup> Edition, Pearson Education, Asia.

#### **References**

1. O' Hagan, A. and Forster, J. (2004): *Advanced Theory of Statistics, Bayesian Inferences*, Vol. 2B, Arnold, London.
2. Rao, C. R. (1984): *Linear Statistical Inference and its Application*, 2<sup>nd</sup> Edition, Wiley Eastern, New Delhi.
3. Stuart A. and Ord. Keith, J. (1986): *Advanced Theory of Statistics*, Vol. II, 5<sup>th</sup> Edition, Charles Griffin And
4. Bansal, K. A. (2007): *Bayesian Parametric Inference*, Narosa Publishing House, New Delhi.

### STAT-402: Multivariate Analysis

**1 Unit/4 Credit (at Least 50 Class Hours)**

**Introduction:** Meaning and Application 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.

**Multivariate Normal Distribution:** Meaning, Derivation and Properties of Normal Distribution, Multivariate Determining Probability Density Contour, Maximum Likelihood Estimator of Mean Vector and Variance Covariance Matrix. Evaluating Normality of Univariate and Multivariate Normal Distribution and Normal Distribution 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.

**Multivariate Sampling Distributions:** The Distribution of Hotelling's  $T^2$  and its Properties. Study of the Wishart Distribution and its Properties, Bartlett's Decomposition and the Generalized Variance, the Distribution of Latent Roots of a Dispersion Matrix.

**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.

**Multivariate Analysis of Variance:** MANOVA and 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.

**Principal Components:** Introduction to the Principal Components Analysis, ML Estimator of the Principal Components and their Variances, Sampling Properties of the Sample Principal Components, Statistical Inference.

**Factor Analysis:** Definition and Purpose of Factor Analysis, the Mathematical Model for Factor Structure, ML Estimators for Random Orthogonal Factors, Estimation for Fixed Factors, Testing the Goodness of Fit of the Factor Model. Factor Interpretation and Transformation.

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

**Discriminant Analysis:** Meaning and Goals of Discriminants and Classification, Fisher's Linear Discriminant Function, Classification Into One of Two and Into One of More than Two Multivariate Populations, Quadratic Discriminators, Test of a Discriminant Function.

**Canonical Correlation and Canonical Variables:** Concepts of Canonical Variables and Canonical Correlation, Estimation of Canonical Correlation and Varieties, Large Sample Statistical Inference of Canonical Correlation.

**Text**  
1. Johnson, R. A. and Wichern, D. W. (2007): *Applied Multivariate Statistical Analysis*, 6<sup>th</sup> Edition, Pearson Education, Asia.

**References**

1. Anderson, T. W. (2003): *Introduction to Multivariate Analysis*, 3<sup>rd</sup> Edition, John Wiley, New York.
2. Izenman, A. J. (2008): *Modern Multivariate Statistical Techniques, Regression, Classification and Manifold Learning*, Springer-Verlag, New York.
3. Mardia, K. V., Kent, J. T. and Bibby, J. M. (1980): *Multivariate Analysis*, Academic Press, London.
4. Everitt, B. And Hothorn, T. (2011): *An Introduction to Applied Multivariate Analysis with R*, 2011<sup>th</sup> Edition, Springer

**STAT-403: Design of Experiments** **1 Unit/4 Credit (at Least 50 Class Hours)**

Covariance Analysis with Two Concomitant Variables.

Analysis of Variance in One-Way, Two-Way and Three-Way Classification with Unequal Number of Observations Per Cell, Test for Additivity, Multiple Comparison Test, Covariance Analysis with Two Concomitant Variables.

Basic Principles in Experimental Design, Completely Randomized Design, Randomized Block Design, Latin Square Design, Analysis with Missing Observations in Randomized Block Design and Latin Square Design, Graeco-Latin Square Design, Efficiency of Designs, Covariance Analysis in Completely Randomized Design, Randomized Block Design, Latin Square Design with Two Concomitant Variance.

Factorial Experiment up to  $p^n$  Series, Asymmetrical Factorial Experiments, Confounding, Partial Confounding, Total Confounding, Balanced Confounding, Fractional Replications, Multiple Comparison Tests, Split-Plot Design, Incomplete Block Design, Balanced Incomplete Block and Partially Balanced Incomplete Block Design with Their Construction, Lattice Design, Youden Square Design.

**Text**  
1. Montgomery, D. C. (2012): *Design and Analysis of Experiments*, 8<sup>th</sup> Edition, John Wiley, New York.

**References**

1. Cochran, W. G. and Cox, G. M. (2000): *Experimental Designs*, 2<sup>nd</sup> Edition, John Wiley, New Delhi.
2. Das, M. N. and Giri, N. C. (1997): *Design and Analysis of Experiments*, 2<sup>nd</sup> Edition, New Age International (P) Ltd., India.
3. Federer, W. T. (1967): *Experimental Design: Theory and Application*, Oxford And IBH, New Delhi.
4. Graybill, F. A. (1961): *An Introduction to Linear Statistical Models*, Vol. I, McGraw-Hill, New York.
5. John, P. W. (1971): *Statistical Design and Analysis of Experiments*, Wiley, New York.

**STAT-404: Sampling Technique II** **½ Unit/2 Credit (at Least 35 Class Hours)**

**Sampling With Varying Probability:** Methods of Selecting PPS Sample, Estimation in PPSWR Sampling, Cumulative Total Method, Lahiri's Method, Sampling with PPSWOR, Desraj's Ordered Estimator, Inclusion Probabilities, Horvitz-Thompson Estimator, Sen-Midzuno Method, Random Group Method, Relative Efficiency of Different Ordered and Unordered Estimators.

**Double Sampling:** Description of the Technique, Double Sampling in Ration, Product and Regression Method of Estimation, Sample Size Determination. Double Sample for Stratification, Two-Phase PPS Sampling.

**Cluster Sampling of Unequal Size:** Single Stage Cluster Sampling of Unequal Sizes, Sampling with Probability Proportional to Size, Horvitz-Thompson Estimator, Brewer's Method, Murthy's Method, the Rao- Hartley- Cochran Method.

**Sub Sampling:** Reasons for Sub Sampling, Sub Sampling with Units of Equals Size, Tow Stage Sampling, Means and Variances in Two-Stage Sampling, Three-Stage Sampling, Sub Sampling with Units of Unequal Sizes, Units Selected with Equal Probabilities- Unbiased Estimator, Units Selected with Equal Probabilities-Ratio To Size Estimate, Estimation Using SRSWOR at both the Stages, Estimation using PPSWR And SRSWOR.

**Successive Sampling:** Sampling in More Occasions, Longitudinal Surveys, Repetitive Surveys, Choice of Study Designs in Operations Research, Experimental and Quasiexperimental Designs.

**Inverse Sampling:** Inverse Sampling with Equal and Unequal Probability.

**Census and Surveys:** Population and Housing Census, Economic Census, Households Expenditure Surveys, Demographic Surveys, Agriculture Survey, Forest Servey.

**Texts**  
1. Raj, D. and Chandhok, P (2013): *Sample Survey Theory*, Create Space Independent Publishing Platform

- Thompson, S. K. (2012): *Sampling*, 3<sup>rd</sup> Edition, Wiley, New York.

## References

- Lohr, S. L. (2010): *Sampling: Design and Analysis, 2nd Edition*, Brooks/Cole, Cengage Learning.
- Chudhuri, A and Stenger, H. (1992): *Survey Sampling Theory and Methods*, Chapman and Hall/CRC.
- Cochran, W. G. (1977): *Sampling Techniques*, 3<sup>rd</sup> Edition, Wiley Eastern, New Delhi.
- Chowdhuri, A. (2010): *Essentials of Survey Sampling*, PHI Learning Private Ltd. New Delhi.
- Murthy, M. N. (1977): *Sampling Theory and Methods*, Statistical Publishing Society, Calcutta.
- Sukhatme P. V. and Sukhatme B. V. (1984): *Sampling Theory of Surveys with Applications*, Indian Society of Agricultural Statistics, New Delhi.

## STAT-405: Data Mining

**½ Unit/2 Credit (at Least 35 Class 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, Hopfield Network, Boltzmann 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.

## Texts

- Dunham, M. H. (2003): *Data Mining: Introductory and Advanced Topics*, 1<sup>st</sup> Edition, Pearson.
- Ibrahim, A. M. (2004): *Fuzzy Logic for Embedded Systems Applications*, Elsevier Science, USA.

## References

- Larose, D. T. (2006): *Data Mining: Methods and Models*, Wiley-Interscience, India.
- Schalkoff, R. (2005): *Pattern Recognition Statistical, Structural and Neural Approaches*, John Wiley and Sons, New York.

## STAT-406: Epidemiology and Biostatistics

**1 Unit/4 Credit (at Least 50 Class Hours)**

### Epidemiology

**Basic Concepts:** Definition, Scope of Epidemiology, uses of Epidemiology.

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

**Types of Epidemiologic 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.

## Biostatistics

**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 for Exponential Distributions:** 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 Extreme Value Distributions:** Inference Procedures for Weibull and Extreme Value Distributions with Type I and Type II Censored Data.

**Exponential Regression Model:** Method of Estimation, Tests of Hypothesis.

## Texts

1. Kenneth, J. Rothman, Timothy L Lash and Sander Green Land (2012): *Modern Epidemiology*, 3<sup>rd</sup> Edition, Lippin Catt.
2. Lawless, J. F. (2003): *Statistical Models and Methods for Life Time Data*, 2<sup>nd</sup> Edition, Wiley Series, New York.
3. Lee, E. T. and Wang, J. W. (2013): *Statistical Methods for Survival Data Analysis*, 4<sup>th</sup> Edition, Wiley Series, New York.

## References

1. Barker, D. J. P. and Hall, A. J. (1991): *Practical Epidemiology*, Churchill Living Stone, Edinburg.
2. Daniel, W. W. (2000): *Bio-Statistics: A Foundation for Analysis in the Health Science*, 7<sup>th</sup> Edition, John Wiley and Sons, New York.
3. Fienberg, S. F. (1980): *The Analysis of Cross-Classified Categorical Data*, 2<sup>nd</sup> 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. Khan, A. Q. (1999): *Epidemiology and Disease Control*, 2<sup>nd</sup> Edition, Dhaka.
7. McCullah, P. and Nelder, J. A. (1982): *Generalized Linear Models*, Chapman and Hall, London.
8. Newman, S. (2001): *Biostatistical Methods in Epidemiology*, Wiley, New York.
9. Sahai, H. and Khurshid, A. (1995): *Statistics in Epidemiology, Methods, Techniques and Applications*, CRC Press, Boca Raton, Florida.

## STAT-407: Advanced Demography

**½ Unit/2 Credit (at Least 35 Class Hours)**

Demographic Transition Theory, Population Policies, Programs in Bangladesh, Changes Option in HPSP, Population Projection, Application and use of Different Demographic Projections with Special Reference to Bangladesh.

Urbanization and Migration, Economic and Social Consequences of Rapid Urbanization and Migration with Respect to Bangladesh.

Birth Averted by FP Program, Bongaarts Model and Proximate Determinants, Targeting and Projection by Bongaarts Model, Estimation of Adult Mortality by Indirect Means (Such as Orphan Hood, Widowhood Methods), Gompertz Model, Reduced Gompertz Model, Estimation of Fertility and Mortality from Two Censuses, Age Distribution, Estimation of Mortality from Census Based Method, Census Coverage and Estimation, Completeness of Coverage of Census and Vital Registration Data.

Population Momentum, Population aging and Health and its Implication.

Important Demographic Surveys.

## Texts

1. Keyfitz, N. and Caswell, H. (2005): *Applied Mathematical Demography*, Springer, Veslag, New York.
2. Shryock, H. S., Siegel, J. S. and Swanson, D. (1976): *The Methods and Materials of Demography*, Condensed Edition, Academic Press, New York.

## References

1. Bangladesh Bureau of Statistics, (1974): *Bangladesh Population Census Report*, Dhaka, Bangladesh.
2. Bogue, D. J. (1969): *Principles of Demography*, John Wiley, New York.
3. Brass, W. (1975): *Methods for Estimating Fertility and Mortality from Limited and Defective Data*, Chapel Hill, North Carolina.
4. Brass, W. (1985): *Advances in Methods for Estimating Fertility and Mortality from Limited and Defective Data for Population Studies*, USA.
5. Brass, W. and Coale, A. (1968): *The Demographic of Tropical Africa*, Princeton University Press, USA.
6. Census Commission, Statistics Division (1979): *Report on the 1974 Retrospective Survey of Fertility and Mortality*, Vol. I, Vol. II, Dhaka, Bangladesh.
7. *Demographic Reports*, BBS, NIPORT.
8. Guillaume, J. W. and Termote, M. G. (1978): *Introduction to Demography Analysis: Principles and Methods*, Plenum Press, USA.
9. Hermalin, A. I. and Entwisle, B. (1980): *The Role of Surveys in the Analysis of Family Planning Programs*, International Union for the Scientific Study of Population, Belgium.
10. Lingner, J. W. (2001): *A Handbook for Population Analysis*, Chapel Hill, North Carolina.
11. Pressat, R. (1974): *A Workbook in Demography*, Methuen, London.



12. Pressat, R. (2008): *Demographic Analysis: Projections on Natality, Fertility and Replacement*, Transaction Publication, India.
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. UNO (1983): *Indirect Technique Demographic Estimation*, Population Studies, No. 81, USA.
15. UNO (1993): *Reading in Population Research Methodology*, Vol. 1 To 6, Chicago.
16. UNO, (1968): *The Concept of Stable Population*, Population Studies, USA.

#### STAT-408: Stochastic Process

½ Unit/2 Credit (at Least 35 Class Hours)

**Stochastic Process:** Definition of Different Types of Stochastic Process, Martingales, Recurrent Events, Delayed Recurrent Events, Markov Chain, Closed Sets, Classification of States, Properties of Communication of States, Chapman-Kolmogorov Equations, First Entrance Decomposition Formula, Ergodic Properties of Irreducible Chains. Periodic Chains, Transient States, Recurrent States.

**Counting Process:** Counting Process, Poisson Process, Stationary and Independent Increment, Arrival and Waiting Time Distribution, Conditional Distribution of Inter-Arrival Time, Compound Poisson Process.

**Renewal Theory:** Distribution of  $N(t)$ , Limit Theorem and their Applications, Renewal Reward Processes.

**Convergence Criteria:** Deterministic Process, Stochastic Process.

**Continuous Time Markov Chain:** Markovian and Non-Markovian Process, Continuous Time Markov Chains, Kolmogorov Differential Equations, Limiting Probabilities.

**Queuing Theory:** Characteristics of Queuing System, Cost Equations, Steady State Probabilities, Exponential Queuing Models, Tandem or Sequential System, M/G/I System, Erlang's Loss System, M/M/K Queue System, Taboo Probabilities, Branching Process.

#### Text

1. Ross, S. M. (2014): *Introduction to Probability Models*, 11<sup>th</sup> Edition, Academic Press, New York.
2. Billingsley, P. (2012): *Probability and Measure*, Anniversary Edition, Wiley, New York.

#### References

1. Feller, W. (1988): *Introduction to Probability Theory and its Applications*, Vol. I and II, Wiley Eastern, New Delhi.
2. Mehedi, J. (1994): *Stochastic Process*, 2<sup>nd</sup> Edition, Wiley Eastern, New Delhi.
3. Minh, D. L. (2001): *Applied Probability Models*, Thomson Duxbury, California.
4. Prabhu, N. U. (1980): *Stochastic Process*, Springer Varleg, New York.
5. Gupta, P. P. and Malik, G. S. (1975): *Measure Theory*, 1<sup>st</sup> Edition, Meerut.

#### STAT-409: Bioinformatics

½ Unit/2 Credit (at Least 35 Class Hours)

**Introduction:** Basic Cell Architecture, the Structure, Content and Scale of Deoxyribonucleic Acid (DNA), History of the Human Genome, Genes and Proteins, Current Knowledge and the 'Central Dogma', why Proteins are Important? Gene and Cell Regulation, when Cell Regulation Goes Wrong? So, what is Bioinformatics?

**Introduction and Bioinformatics Resources:** Knowledge of Various Databases and Bioinformatics Tools Available at These Resources, the Major Content of the Databases, Nucleic Acid Sequence Databases (Genbank, EMBL, DDBJ), Protein Sequence Databases (SWISS-PROT, TrEMBL, PIR, PDB), Genome Databases (NCBI, EBI, TIGR, SANGER), Other Databases of Patterns/Motifs/System Biology (Gene and Protein Network Database and Resources)

**Sequence Analysis:** Various File Formats for Bio-Molecular Sequences: Genbank, Fasta, Gcg, Msf, Nbrf-Pir Etc., Basic Concepts of Sequence Similarity, Identity and Homology, Definitions of Homologues, Orthologues, Paralogs. Basic Concept of a Scoring Matrix, PAM and BLOSUM Series. Sequence-Based Database Searches: what are Sequence-Based Database Searches, BLAST and FASTA Algorithms, Various Versions of Basic BLAST and FASTA.

**Pairwise and Multiple Sequence Alignments:** Basic Concepts of Sequence Alignment, Needleman and Wunsch, Smith and Waterman Algorithms for Pairwise Alignments, Progressive and Hierarchical Algorithms for MSA. Use of Pairwise Alignments and Multiple Sequence Alignment for Analysis of Nucleic Acid and Protein Sequences and Interpretation of Results.

**Markov Chains and Hidden Markov Models:** Introduction to Markov Chains and HMM using Markov Chains for Discrimination of Biological Sequences. Forward and Backward Algorithms, Parameters Estimation for Hmms. Hmms for Pairwise and Multiple Sequence Alignments. Profile Hmms.

**Machine Learning and Bioinformatics:** Introduction to Various Machine Learning Techniques and their Applications in Bioinformatics. Genetic Algorithms, Support Vector Machine, Neural Networks and their Practical Applications towards the Development of New Models, Methods and Tools for Bioinformatics.

#### Texts

1. Edward Keedwell and Ajit Narayanan, (2005), *Intelligent Bioinformatics: The Application of Artificial Intelligence Techniques to Bioinformatics Problems*, John Wiley and Sons Ltd.
2. Warren Ewens and Gregory Grant, (2005), *Statistical Methods in Bioinformatics: An Introduction*, 2nd Edition, Springer
3. Jin Xiong, (2006), *Essential Bioinformatics*, Cambridge University Press.

## References

1. Lesk, A., (2014), *Introduction to Bioinformatics*, 4<sup>th</sup> Edition, Oxford University Press.
2. Baxevanis, A. D., and B. F. Ouellette, (2004), *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (Vol. 43), John Wiley and Sons.
3. Mathur, S. K., (2010), *Statistical Bioinformatics: with R*, Academic Press.
4. Devid W. Mount, (2004), *Bioinformatics: Sequence and Genome Analysis*, Second Edition, Cold Spring Harbor Laboratory Press.
5. R. C. Rastogi, (2009), *Bioinformatics: Concepts, Skills and Applications*, Second Edition, CBS Publishers and Distributions.

## STAT-410: Categorical Data Analysis

1 Unit/4 Credit (at Least 50 Class Hours)

**Introduction-Distributions and Inference for Categorical Data:** Categorical Response Data, Distributions for Categorical Data, Statistical Inference for Categorical Data, Statistical Inference for Binomial and Multinomial Parameters, Bayesian Inference for Binomial and Multinomial Parameters.

**Contingency Tables and Inference for Two-Way Contingency Tables:** Probability Structure for Contingency Tables, Comparing Two Proportions, Conditional Association in Stratified  $2 \times 2$  Tables, Measuring Association in  $I \times J$  Tables. Confidence Interval for Association Parameters, Testing Independence in Two-Way Contingency Tables, Following up Chi-Square Tests, Two-Way Tables with Ordered Classifications, Small-Sample Tests of Independence, Bayesian Inference for Two-Way Contingency Tables, Extensions for Multiway Tables and Nontabulated Responses,

**Generalized Linear Model:** Generalized Linear Model, Generalized Linear Models for Binary Data, Generalized Linear Models for Counts, Moments and Likelihood for Generalized Linear Models, Inference and Model Checking for Generalized Linear Models, Fitting Generalized Linear Models, Quasi-Likelihood and Generalized Linear Models.

**Logistic Regression-Building and Applying:** Interpreting Parameters in Logistic Regression, Inference for Logistic Regression, Logistic Models with Categorical Predictors, Multiple Logistic Regression, Fitting Logistic Regression Models, Strategies in Model Selection, Logistic Regression Diagnostics, Summarizing the Predictive Power of a Model, Mental-Haenszel and Related Methods for Multiple  $2 \times 2$  Tables, Detecting and Dealing with Infinite Estimates, Sample Size and Power Consideration.

**Models for Multinomial Responses:** Nominal Responses: Baseline-Category Logit Models, Ordinal Responses: Cumulative Logit Models, Ordinal Responses: Cumulative Link Models, Alternative Models for Ordinal Responses, Testing Conditional Independence In  $I \times J \times K$  Tables, Discrete-Choice Multinomial Logit Models, Bayesian Modeling of Multinomial Responses.

**Model for Matched Pairs:** Comparing Dependent Proportions, Conditional Logistic Regression for Binary Matched Pairs, Marginal Models for Square Contingency Tables, Symmetry, Quasi-Symmetry, and Quasi-Independence, Measuring Agreement between Observers, Bradley-Terry Model for Paired Preferences, Marginal Models and Quasi-Symmetry Models for Matched Sets.

**Clustered Categorical Data- Marginal and Transitional Models:** Marginal Modeling: Maximum Likelihood Approach, Generalized Estimating Equations Approach, Quasi-Likelihood and its GEE Multivariate Extension, Transitional Models: Markov Chain and Time Series Models.

**Clustered Categorical Data-Random Effect Models:** Random Effects Modeling of Clustered Categorical Data, Binary Responses: Logistic-Normal Model, Examples of Random Effect Models for Binary Data. Random Effect Models for Multinomial Data, Multilevel Modeling, GLMM Fitting, Inference and Prediction, Bayesian Multivariate Categorical Modeling.

## Text

1. Agresti, A. (2012): *Categorical Data Analysis*, 3<sup>rd</sup> Edition, John Wiley and Sons, New York.

## Reference

1. Powers, D. A. and Xie, Yu. (2008): *Statistical Methods for Categorical Data Analysis*, 2<sup>nd</sup> Edition, Emerald Group Publishing Ltd., London.

## STAT LAB-411: Statistical Data Analysis VIII

½ Unit/2 Credit (at Least 35 Class Hours)

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks for Each Group)

### Group A (Marks: 30)

(Related Course - STAT-401: Bayesian and Classical Inference)

Drawing Samples from Bivariate Normal, Multivariate Normal, Gamma, Beta and Other Distributions.

Estimation of Population Parameters of Different Distributions by Different Methods, Inference about Mean Vector and Variance-Covariance Matrix of Multivariate Population, Comparison of Several Multivariate Means.

Estimation of Confidence Interval for Mean and Variance.

Test of Simple Hypothesis for Mean and Variance, Drawing Power Curve, Test of Multiple Regression Coefficients, Test of Multiple Correlation Coefficients, Test of Mean Vector.

Bayesian Contingency Table Analysis.

**Group B (Marks: 20)**

(Related Course - STAT-403: Design of Experiments)

Multiple Comparison, Test of Additivity of Model in Case of Two-Way Classification, Analysis of Split-Plot, Split-Split-Plot Design, Analysis of BIB Design, Recovery of Inter-Block Information in BIB Design, Analysis of Youden Spare Design, Covariance Analysis, Analysis of Groups of Experiments.

**STAT LAB-412: Statistical Data Analysis IX**

**½ Unit/2 Credit (at Least 35 Class Hours)**

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks for Each Group)

**Group A (Marks: 30)**

(Related Course - STAT-402: Multivariate Analysis)

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, Principal Components, Factor Analysis, Canonical Analysis, Logistic Analysis, Classification And Grouping Techniques Of Data By Discrimination And Classification, Cluster Analysis of Categorical Data By Different Measures.

**Group B (Marks: 20)**

(Related Course - STAT-410: Categorical Data Analysis)

Chi-Square Test, Exact Test for Small Samples, Association in Three-Way Tables. Generalized Linear Model, Glms for Binary Data, Glms for Count Data, Inference and Model Checking, Fitting Generalized Linear Models, Logistic Regression-Building and Applying: Interpreting Logistic Regression, Inference for Logistic Regression, Multiple Logistic Regression, Strategies in Model Selection, Model Checking, Multi-Category Logit Models, Logit Models for Nominal Response, Model for Matched Pairs: Comparing Dependent Proportions, Measuring Agreement, Loglinear Models, Loglinear Models For 2-Way and 3-Way Tables, Inference for Loglinear Model.

**STAT LAB-413: Statistical Data Analysis X**

**½ Unit/2 Credit (At Least 35 Class Hours)**

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks For Each Group)

**Group A (Marks: 20)**

(Related Course - STAT-404: Sampling Technique II)

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, Related Precision of Different Sampling Scheme.

**Group B (Marks: 30)**

(Related Course - STAT-408: Applied Probability and Stochastic Process)

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.

**Estimation and Hypothesis Testing:** Transition Probabilities of Markov Chain, Asymptotic Behavior of TPM Determination of Different Properties of Transition Probability Matrix, Homogeneous and Non-Homogeneous Poisson Process, Determination of Steady State Probabilities for Different Queuing Systems.

**STAT LAB-414: Statistical Data Analysis XI**

**½ Unit/2 Credit (At Least 35 Class Hours)**

(Tutorial: 20% Marks, Attendance: 10% Marks, Final: 70% Marks for Each Group)

**Group A (Marks: 30)**

(Related Course - STAT-405: Data Mining)

Determination of Partition of Set of Data by Sum of Squares of Errors, Clustering Criteria, Hierarchical Clustering by Nearest Neighbor, Further Neighbor, K-Means Method or Algorithm, Determination of Minimum Distance Decision Boundary, Performing K-NN Classification Using Euclidean and Statistical Matrix, Application of Different Rules of Data Mining, Classification by Regression Tree, Decision Tree, Bayesian Approach, Neural Network.

**Group B (Marks: 20)**

(Related Course - STAT-406: Epidemiology and Biostatistics)

**Plotting Procedures:** Plots Involving Estimated Survivor and Hazard Functions, Probability Plots.

**Estimation of Relative Risk:** Cross Product Ratio, Prevalence Rate, Incidence Rate.

**Three-Dimensional Contingency Tables:** Fitting of Log Linear Models, Goodness of Fit Test.

**Family of Exponential Distribution:** Estimation of Parameters of Exponential, Weibull and Extreme Value Distribution for Censored Data, Fitting of Exponential Regression Model, Solution of Problems Regarding Epidemiology.