University of Dhaka
Department of Statistics
Syllabus for 4-year Undergraduate Program
Starting Session: 2023-2024

Preamble:
The Undergraduate Program in statistics under the Faculty of Science, Dhaka University, is a 4-year program consisting of four academic sessions. The students enrolled in the program will have to complete a total of **137** credits in 4 years. Each course will comprise of 70% marks for the final examination and 30% marks for the in-course assessment. There will be some Practical (Statistical computing) courses to learn the applications of statistical techniques. For the practical courses, there will be 40% marks for the in-course assessment and the remaining 60% for the final examination. As a part of the in-course assessment, 5% marks will be awarded on the basis of attendance under prescribed rules of the Science Faculty. For the undergraduate research project, 60% marks will be for the report, 20% for the presentation and 20% based on meetings with the supervisor. Students must submit the research report to the examination committee followed by a presentation before the last day of classes. Each report will be examined by two external examiners.

The year-wise distribution of credits is as follows:

First Year	:	30 credits
Second Year	:	33 credits
Third Year	:	36 credits
Fourth Year	:	38 credits
Total	**:**	**137 credits**

List of Courses

First Year:

Course Number	**Course Title**	**Credit**
Stat H-101	Introduction to Statistics	4
Stat H-102	Probability and Probability Distributions	4
Stat H-103	Elementary Sample Survey	2
Stat H-104	Basic Mathematics	2
Stat H-105	Calculus	4
Stat H-106	Linear Algebra	4
Stat H-107	Introduction to Economics	4
Stat H-108	Computing I (Programming with Python)	2
Stat H-109	Computing II (Introduction to Statistics; Elementary Sample Survey)	2
Stat H-110	Viva Voce	2
Total		**30**

Second Year:

Course Number	Course Title	Credit
Stat H-201	Theory of Estimation	4
Stat H-202	Mathematical Statistics	4
Stat H-203	Introduction to Demography	3
Stat H-204	Economic Statistics	4
Stat H-205	Operations Research	3
Stat H-206	Ordinary Differential Equations	3
Stat H-207	Numerical Analysis and Advanced Calculus	3
Stat H-208	Real Analysis	3
Stat H-209	Computing III (Programming with R)	2
Stat H-210	Computing IV (Introduction to Demography; Economic Statistics)	2
Stat H-211	Viva Voce	2
Total		**33**

Third Year:

Course Number	Course Title	Credit
Stat H-301	Test of Hypothesis	4
Stat H-302	Sampling Techniques	3
Stat H-303	Regression Analysis	4
Stat H-304	Epidemiology	4
Stat H-305	Industrial and Official Statistics	2
Stat H-306	Mathematical Demography and Actuarial Statistics	3
Stat H-307	Simulation	3
Stat H-308	Introduction to Big Data	2
Stat H-309	Research Methodology	3
Stat H-310	Computing V (SPSS and SAS)	2
Stat H-311	Computing VI (STATA)	2
Stat H-312	Computing VII (Regression Analysis; Mathematical Demography and Actuarial Statistics)	2
Stat H-313	Viva Voce	2
Total		**36**

Fourth Year:

Course Number	Course Title	Credit
Stat H-401	Multivariate Analysis	3
Stat H-402	Time Series Modeling	3
Stat H-403	Design and Analysis of Experiments	4
Stat H-404	Econometrics	4
Stat H-405	Survival Analysis	3
Stat H-406	Stochastic Process	3
Stat H-407	Generalized Linear Models	3
Stat H-408	Introduction to Data Science	3
Stat H-409	Comprehensive	2
Stat H-410	Computing VIII (Multivariate Analysis; Design and Analysis of Experiments)	2
Stat H-411	Computing IX (Time Series Modeling; Survival Analysis)	2
Stat H-412	Computing X (Econometrics; Generalized Linear Models)	2
Stat H-413	Research Project	2
Stat H-414	Viva Voce	2
Total		**38**

Detailed Syllabus: First Year

Stat H-101: Introduction to Statistics **4 Credits**

Introduction: Statistics - past and present, its nature and characteristics, population and sample, descriptive and inferential statistics, scope and applications of statistics, abuse of statistics; some key terms and mathematical notations for summation and multiplications.

Measurement scales and variable: Types and classification of variables; data: types of data, sources of data, data collection tools, questionnaire and schedule, construction of questionnaire, principles and other problems of data collection.

Data classification: The smallest unit of data and its use, nominal class limits, actual class limits, number of classes, equal and unequal class intervals.

Data presentation in tables: Construction of table: univariate table (categorical), cross-table, frequency distribution table.

Graphical presentation of data: Details of different types of graphs and charts with their relative merits and demerits.

Characteristics of statistical data: Concept and measures of central tendency, dispersion, quantiles, percentile rank; concept and measure of skewness and kurtosis; moments, types of moments, general relations between moments and their uses, detailed properties of these measures, interpretations of data with these measures.

Exploratory data analysis: Stem-and-leaf plot, box plots, outliers and 5-number summaries.

Correlation analysis: Bivariate data, scatter diagram, construction of bivariate frequency distribution table, the simple correlation, rank correlation, Kendall's Tau correlation, Kendall's coefficient of concordance, the point-biserial correlation coefficient, the biserial correlation coefficient, the fourfold correlation coefficient, the tetrachoric correlation coefficient, properties of correlation, correlation ratio and intraclass correlation.

The simple regression: Basic concept of regression, regression model, estimation of parameters (OLS method) in regression model, interpreting the estimators.

Text

Steel, R.G.D., Torrie, J.H. and Dickey, D.A., (1997), Principles and Procedures of Statistics, 3rd Edition.

References

1. Downe, N. M. and Heath, R. W. (1970), Basic Statistical Methods, Harper International, USA
2. Larson, R. and Farber, B., (2003), Elementary Statistics, Prentice-Hall, Inc.
3. Mostafa, M.G., (1972), Methods of Statistics
4. Newbold, P., Carlson, W.L. and Thorne, B., (2007), Statistics for Business and Economics, 5th Edition, Prentice-Hall, Inc.
5. Jalil, M. A. and Ferdous, R., (1999), Basic Statistics Methods and Applications, Robi Publications

6. M. N Islam, M.N., (2010), An Introduction to Statistics and Probability, Book World, Dhaka
7. Wesis, N., (2007), Introduction to Statistics, 7th edition, Addison Wiley
8. Tukey, J., (1977), Exploratory Data Analysis, Wiley, N.Y.

Stat H-102: Probability and Probability Distributions **4 Credits**

Elements of set theory: Fundamentals of set, operations with set, laws of set.

Elements of probability: Experiment, random experiment, sample space, events, event space, union and intersection of events, different types of events.

Basic concepts of probability: Different approaches of defining probability – classical, axiomatic, empirical and subjective, laws and theorems of probability, conditional probability, Bayes' theorem and its uses and importance in statistics.

Random variable and its probability distribution: Discrete and continuous random variables, probability mass function, probability density function, distribution function, function of random variable and its distribution, joint distribution, marginal and conditional distributions, independence of random variables.

Mathematical expectation: Concept, expectations of sums and products of random variables, conditional expectation and conditional variance, moments and moment generating functions, cumulants and cumulant generating functions, relation between moments and cumulants, probability generating functions, characteristic function.

Some basic distributions: Detailed study of binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, gamma, beta distributions.

Text

Ross, S., (2008). A First Course in Probability, publication-Pearson

References

1. Hoq, S., (1996), Probability: An Introduction, Wiley
2. Roy, M.K., (1996), Fundamentals of Probability and Probability Distribution, 1st edi., Wiley
3. Islam, M.N., (2010), An Introduction to Statistics and Probability, Book World, Dhaka
4. Uspensky, J.V., (1937), Introduction to Mathematical Probability, McGraw-Hill
5. Cramer, H., (1955), The Elements of Probability, Wiley and Sons, N.Y.
6. Feller, W., (1957), Introduction to Probability Theory and Its Applications, Wiley and Sons, N.Y.
7. Ayres, F., (1998), Set Theory, Schaum Series, McGraw-Hill
8. Pattel, K., Kapadia, and Owen, D.B., (1976), Handbook of Statistical Distributions. pub: New York: M. Dekker
9. Parzen, E., (1964), Modern Probability and its Application, Wiley and Sons, N.Y.
10. Paul, L. Meyer., (1970), Probability, Addison-2nd, Wesley, Mass., U.S.A.
11. Rohatgi and Saleh., (2015), An introduction to probability and statistics, Addison-3rd, John & Wiley
12. Hogg and Tanis., (2001), Probability and Statistical inference, 6th ed., Prentice Hall, N.Y.

Stat H-103: Elementary Sample Survey **2 Credits**

Preliminaries in survey: Observation and sampling units, population, sample, sampling frame, census and sample survey.

Basic concept of sample survey: Basic principles of sample survey, various steps involved in a sample survey, pilot survey, relative advantages, disadvantages and suitability of complete and sample enumeration; uses of sample survey, requirements of a good sample design, role of sampling theory.

Various methods of data collection: Questionnaire and schedule, basic points to be considered while preparing a questionnaire, open and closed questionnaire.

Sampling: Random and non-random sampling, method of drawing random and non-random sample, sampling and non-sampling errors.

Sampling techniques: Simple random sampling (SRS), stratified sampling, systematic sampling, and cluster sampling; drawing of samples based on those basic sample designs, advantages and disadvantages of these sampling techniques with real life examples.

Estimation: Estimates of population values, bias and its effect, precision and accuracy of estimates based on simple random sampling (SRS) and stratified sampling.

Text

Lohr, S.L., (2005), Sampling Design and Analysis, Addison-3rd, pub: Brooks/Cole, USA

References

1. Cochran, W.G., (1977), Sampling Techniques, 3rd edition, John & Wiley sons
2. Levy, P.S. and Lemeshow, S., (2008), Sampling of Populations, 4th edition, Wiley
3. Kish, L., (1965), Survey Sampling, John & Wiley sons
4. Singh, D and Chaudhury, F.S., (1987) Theory and Analysis of Sample Survey design. John & Wiley sons Inc.
5. Mendelhall, Ott, and Scaeffer., (2011), Elementary Survey Sampling, 7th Edition, Thomsom-Brooks/Cole, USA
6. Sukhatme, P.V., (1954), Sampling theory of Surveys with Application, 2nd Ed. Asia Publishing House, London
7. Yates, F., (1960), Sampling Methods for Censuses and Surveys. 3rd edition, Hafner Publishing Company, N.Y.
8. Islam, M.N., (2008), An Introduction to Sampling Methods, Book World

Stat H-104: Basic Mathematics **2 Credits**

Set theory: Sets and subsets, set operations, family of sets, De Morgan's laws, different types of relations and functions, images and inverse images of sets.

The real number system: Field and order properties, natural numbers, integers and rational numbers, absolute value, basic inequalities, inequalities involving means, powers, inequalities of Cauchy, Chebyshev, and Weierstrass; the complex number system, geometrical representation of polar form, field of complex numbers, De Moivre's theorem and its applications.
Elementary number theory: Divisibility, fundamental theorem of arithmetic, basic property of congruence.

Summation of finite series: Arithmetic-geometric series, method of difference, successive differences.

Theory of equations: Synthetic division, number of roots of polynomial equations, relations between roots and coefficients, multiplicity of roots, symmetric functions of roots, De Cart's rule of signs, transformation of equations.

Geometry: Graphical solutions of simultaneous, quadratic and cubic equations, graphs of logarithmic, exponential, conic functions.

Convergence and divergence: Different tests for convergence, absolute convergence, radius and interval of convergence.

Text
John Bird., (2005), Basic Engineering Mathematics 4th ed. Elsvier, Amstendam

References

1. Ayres, F., (1995), Theory and Problems of modern Algebra, McGraw-hill
2. S.Lipschutz., (1964), Set Theory, Schaum's Outline Series. 2nd edition., McGraw-Hill
3. S. barnard & J.M. Child., (1959), Higher Algebra. ST Martins Press
4. W.L. Ferrar., (1953), Algebra. Reprinted edition, Oxford University Press
5. P.R. Halmos., (1960), Naïve Set Theory. Springer
6. Durall & Robson., Differential Calculus

Stat H-105: Calculus **4 Credits**

Group A: Differential Calculus

Functions and their graphs (polynomial and Rational functions, logarithmic and exponential functions, trigonometric functions and their inverses, hyperbolic functions and their inverses, combination of such functions); limits of functions: definition, basic limit theorems, limit at infinity and infinite limits; continuous functions on closed and boundary intervals; differentiation: tangent lines and rates of change, definition of derivative, one sided derivative, rules of differentiation (with applications), linear approximations and differentials, successive

differentiation, Leibnitz theorem, Rolle's theorem, Lagrange's mean value theorems; extrema of functions, problems involving maxima and minima.

Vector-valued functions of a single variable: limits, derivatives and integrals.

Partial differentiation: functions of several variables, limits and continuity, partial derivatives with constrained variables.

Taylor's formula, extrema of functions of several variables, Lagrange's multiplier.

Applications in Statistics.

Group B: Integral Calculus

Antiderivatives and indefinite integrals, techniques of integration, definite integration using antiderivatives.

Definite integral as a limit of a sum, the fundamental theorem of calculus, integration by reduction.

Application of integration: plane areas, solids of revolution, volumes by cylindrical shells, volumes by cross-sections, arc length and surface of revolution, multiple integrals: double and triple integrals; and iterated integrals, area as a double integral, double integrals in polar form, volume as a triple integral.

General multiple integrals, change of variables in multiple integrals, Jacobians.

Applications in statistics.

Text

Stewart, J., (2006), Calculus: early transcendental (Stewart's calculus series), 1st edition, Thomsom-Books/Cole

References

1. Rdwanls, J., (1994), Differential Calculus, Macmillan, London.5th edition, Wiley
2. H. Anton et al., (1995), Calculus with Analytic Geometry. 5th edition, Wiley
3. E.W. Swokowski., (1992), Calculus with Analytic Geometry, Wadsworth Publishing co Inc.
4. L. Bers & P. Karal, (1976), Calculus, Winton
5. S. Lang., (1986), A first Course in Calculus. 5th edition, Springer
6. S. Lang., (1973), Calculus of several variables. Wesley Publishing Company

Stat H-106: Linear Algebra **4 Credits**

Vector and vector set: Definition of a vector, different types of vectors, geometrical interpretation, length and angle between two vectors, operation with vectors, vector set, linearly dependent and independent set of vectors, sweep-out method, orthogonal set, normalization, Gram-Schmidt orthogonalisation process, subset and superset of vectors, related theorems.

Vector spaces: Spanning set of vectors, vector spaces and sub-spaces, their geometric interpretation, rank and basis of vector spaces and sub-spaces, orthogonal and orthonormal basis, related theorems.

Determinants: Matrix and vector, square matrix and determinants, ideas of minors and co-factors, product of determinants, properties of determinants, different types of determinants, solution of equations with the help of determinants, evaluation of $n \times n$ determinants.

Matrices: Different types of matrices, definitions with examples, matrix operations, properties of such operations, rank and elementary transformation of matrices, diagonal reduction of a matrix, related theorems of ranks, trace of a matrix, its properties with proofs.

Inverse of a matrix: Definition with examples, different methods of finding inverse of a matrix, properties of such inverses with proofs.

System of linear equations: Introduction, types of linear equations - homogeneous system, non-homogeneous system, consistent and inconsistent unique solution, different methods of solution of such equations: Gaussian elimination; Cramer's rule, sweep-out method, using matrix inverse, related theorems on system of linear equations.

Generalised inverses (g-inverses): Definition, methods of finding g-inverses, properties of g-inverses existence, uniqueness, other properties, kinds of g-inverses, application of g-inverses in the solution of system of equations.

Kronecker sum and product of matrices: Operational conformability of matrices and vectors, definitions of Kronecker sum and product of matrices, properties and uses of Kronecker products.

Quadratic forms: Definition with examples, classification of quadratic forms, latent roots and latent vectors of matrices, canonical form of a quadratic form, rank, index and signature; theorems of eigen values, eigen vectors and quadratic forms.

Matrices of special types: Orthogonal matrices - definition with examples, their properties with proofs, idempotent and nilpotent matrices - definition with examples, their properties with proofs; patterned matrices - definition, examples, their properties, rank; Hadamard matrix - definition with example and properties.

Differentiation involving vectors and matrices, linear transformation.

Text

Hadley, G., (1993), Linear Algebra, Narosa, New Delhi

References

1. Santinarayan., (1985), A Text Book of Matrices, 8th Edition, S. Chand and Co., New Delhi
2. Anton, H. and Rorres. C., (2005), Elementary Linear Algebra,4th edition, Wiley
3. Rahman, A., (2006), College Linear Algebra. Nahar Book Depo, Banglabazar, Dhaka
4. Searle, S.R., (1982), Matrix Algebra useful for Statistics, Wiley, N.Y.
5. Graybill, A., (1982), Matrics with Application in Statistics, Wadsworth & Co. 2nd Ed., N.Y.
6. Searle, S.R., (1971), Linear Models, 2nd edition, Wiley, N.Y.
7. Rao, C.R. and Mitra., (1971), Generalised Inverses and Its Applications. John Wiley & Sons, N.Y.
8. Franklin, A.B., (1969), Matrices with Applications in Statistics, 2nd edition. Wordsworth International Group
9. Schaum Series., (1981), Linear Algebra. Wiley
10. Aitken, A.C., (1982), Determinant and Matrices, Oliver and Boyd, London

Stat H-107: Introduction to Economics **4 Credits**

Basic concepts: Definition and scope of economics, basic economic problem: scarcity and choice, opportunity cost, the question of what to produce, how to produce and how to distribute output, production possibility frontier, economic systems – definition and examples of command economy, market economy and mixed economy; microeconomics and macroeconomics, normative economics and positive economics.

Demand and supply: Definition, factors influencing them, demand and supply schedules and curves, law of demand, market demand and market supply, law of supply, movements along and shifts in demand curve, shifts in supply curve, market equilibrium, application of demand and supply.

Elasticity: Elasticity of demand and supply - concepts, definitions and problems associated with calculations, price elasticity, income elasticity and cross elasticity of demand, factors influencing them, types of demand curves depending on elasticity of demand, computation of elasticity from demand function and family budget data.

Consumer behaviour and utility: Basic concepts, ordinal and cardinal measurements of utility, total utility and marginal utility, law of diminishing marginal utility, utility maximization, determination of demand function from utility function and budget constraint, substitution and income effects and the law of demand, Slutsky equation, diamond-water paradox.

The indifference curve analysis: Concepts, consumer's indifference curve: properties, rate of commodity substitution, consumer's equilibrium, effects of income and price change on equilibrium.

Theory of income distribution: Macroeconomic concepts, definitions of savings, investment, employment and national income, Keynesian theory of national income determination.

Division of labour in Economics, localization of industry: meaning, causes and remedies and concepts of international trade.

Concept of perfect competition, monopoly, pure monopoly, oligopoly, duopoly, short run, long run.

Text

Samuelson, P.A. and Nordhaus, W.D., (1948) Economics, 16th Edition, McGraw-Hill Inc.

References

1. Dr. H. L. Ahuja., (2009), Principles of Economics, 18th Edition. S Chand.
2. Lipsey, R.G. and Crystal, K.A., (1995), An Introduction to Positive Economics, Oxford University
3. Colander, C., (2007), Microeconomics, 7th Edition. McGraw-Hill Inc.
4. Ferguson, C.E. and Gould, J.P., (1975), Microeconomic Theory. 4th Edition.
5. Kjhng D Samuelson, P.A., Economics., (2009), 10th Edition., McGraw-Hill Inc.
6. D Samuelson, P.A., Economics., (2009), 10th Edition, McGraw-Hill Inc.
7. Varian, H.R., (2010), Intermediate Microeconomics: A Modern Approach, 8th Edition, W.W. Norton & Company.

Stat H-108: Computing I (Programming with Python) 2 Credits

Installing Python, anaconda, spyder, Jupyter notebook, colab; Python editors, essential Python libraries, the basic syntax of a Python program.

Python data types, expressions and variables; lists, tuples, sets, and dictionaries; writing conditions, loops, and functions; Flask or Django, covering topics such as routing, templates, and interacting with databases.

A brief matplotlib API primer, plotting functions in pandas, plotting maps, visualizing data, Python visualization tool ecosystem, reading and writing data in text format, binary Data formats, interacting with HTML and Web APIs, interacting with databases-storing and loading data in MongoDB, combining and merging data dets, reshaping and pivoting, data transformation, string manipulation.

Text

McKinney W., (2022). Python for data analysis: Data wrangling with Pandas, NumPy, and Jupiter. 3rd edition. O'Reilly

Reference

Guttag, J.V., (2016). Introduction to computation and programming using Python. 2nd edition. MIT Press

Stat H-109: Computing II (Introduction to Statistics; Elementary Sample Survey)
2 Credits

Introduction to Statistics

Classification of variables, data classification and tabulation, construction of frequency distribution table, graphical representation of data, measures of central tendency, dispersion, skewness and kurtosis.

Exploratory data analysis: stem and leaf plot, box plot.

Simple correlation co-efficient and fitting of regression lines, computation of Pearson's correlation from bivariate frequency table, rank correlation, correlation ratio, intraclass correlation.

Elementary Sample Survey

Drafting questionnaire, construction of direct interview schedules (semi structured).

Drawing random sample: practical problems of drawing sample by the methods of SRS, systematic sampling, stratified sampling and cluster sampling.

Reference
See the references for **Stat H-101** and **Stat H-103**.

Stat H-110: Viva Voce **2 Credits**

Detailed Syllabus: Second Year

Stat H-201: Theory of Estimation **4 Credits**

Concept of statistical inference: Introduction to estimation theory, problem of estimation, types of estimation.

Methods of finding point estimators: Method of moments, method of maximum likelihood, method of least squares, method of minimum distance and Bayes estimation method, properties of estimators obtained using different methods.

Criteria of a good estimator: Unbiasedness, mean squared error (MSE), Cramer Rao inequality, use of Cramer Rao inequality, Rao Blackwell theorem in finding UMVUE, MVB estimator, efficient estimator, consistency.

Sufficiency: Sufficiency**,** factorization theorem, families of distributions, exponential family, minimal sufficiency and complete sufficiency, ancillary statistic and its relation with complete sufficient statistic and UMVUE; Lehmann-Scheffe theorem, Basu's theorem and their applications.

Interval estimation: Introduction, confidence interval and confidence limit, confidence coefficient.

Inverting a test statistics, pivotal quantities, pivoting the CDF, confidence interval for mean, proportion, difference of means, difference of proportions, variance, ratio of variance, correlation coefficient, regression coefficient etc.; approximate ML intervals, other large sample intervals.

Text

Hogg, R.V. and Craig, A.T., (2005), Introduction to Mathematical Statistics, McMillan-Collierm, N.Y.

References

1. Mood, Graybill and Boes., (1974), Introduction to the Theory of Statistics, 3rd Ed., McGraw-Hill
2. Casella., G., and Berger, R.L., (2002), Statistical Inference, 2nd Edition, Thomson
3. Rao, C.R., (2008), Linear Statistical Inference and its Applications, Wiley
4. Kendall & Stuart., (1979), The Advanced Theory of Statistics, Vol. I & II. Charless Griffin co. ltd.
5. Ferguson., (1967), Mathematical Statistics: A Decision Theoretic Approach. Academic Press Inc.
6. Gramer., (1962), Mathematical Methods in Statistics. Princeton University Press
7. Cox, D.R. & Hinkley, U., (1965), The Theory of Statistics, Methuem, London
8. Lehmann., (1998), Theory of Point Estimation., Springer

Stat H-202 Mathematical Statistics **4 Credits**

Review: Discrete and continuous random variables, probability mass function, probability density function, mathematical expectations, empirical rule and Chebyshev's rule with real life problems.

Distribution of function of random variables: Method of distribution functions, method of transformations, method of moment generating functions, distribution of sum, difference, product and quotient of random variables, law of large numbers.

Sampling distributions: Definition of sampling distribution, examples from discrete and continuous populations, difference from probability distribution, central limit theorem with real life applications.

Exact sampling distributions: Distribution of sample mean and variance and their independence for normal population, Chi-square, t and F distributions with their uses in statistics. Standard errors of statistics with their large sample approximations. Fisher's Z-transformation, transformation of variables including square root, log, sin-inverse etc.

Order statistics: Definition, the role of order statistics in practical applications, distribution of functions of order statistics for both discrete and continuous cases, joint distribution of order statistics, distribution of range and some other statistics.

Text

Mendenhall, Richard and Denis, (2008), Mathematical Statistics with applications. 7th edition, Duxbary press, Boston

References

1. Hogg, R.V. and Craig, A.T., (2013), An introduction to Mathematical Statistics, 7th edition, McMillan-Collierm, N.Y.
2. Mood, Graybill and Boes., (2007), Introduction to the Theory of Statistics, 3rd edition, McGraw-Hill
3. Gupta, S.C. and Kapoor, V.K., (1970), Fundamentals of Mathematical Statistics. 10th edition, Sultan Chand & sons, New Delhi
4. Balakrishnan, N. & Cohen, A.C., (1993), Order Statistics and Inference: Estimation Methods, Academic Press, Boston
5. Hoel, P.G., (1966), Introduction to Mathematical Statistics, 3rd edition, John Wiley & Sons, N.Y.

Stat H-203: Introduction to Demography **3 Credits**

Basic concepts of population studies: Population studies and demography, scope of demography, population and demographic variables.

Sources of demographic data: Primary and secondary sources, vital registration, survey and census, sources of errors.

Demographic rates and ratios: Concepts of rates, ratios, proportions and probability, crude rates and refined rate.

Population change: Concept of population change, age-sex composition, population pyramid, population growth, measurement of population growth, cohort and Lexis diagram.

Fertility and reproduction: Concept of fertility, reproduction, fecundity, sterility, measurements of fertility and reproduction, cohort fertility, parity progression ratio, differentials of fertility.

Mortality: Concepts of mortality and morbidity, measures of mortality, standardization, trends in mortality, differentials of mortality, measures of morbidity.

Marriage: Concept of marriage, estimation of mean and median age at marriage, singulate mean age at marriage, Coale's indices, their relationships and contributions to fertility differentials.

Migration: Concept, types and measures of migration, consequence, determinants and trends of migration.

Text

Swanson, D. A. and Siegel, J.S., (2004), The Methods and Materials of Demography. 2nd edition

References

1. Pollard, A.H., (1990), Farhat, Y. & Pollard, G.N., Demographic Technique. Subsequent edition, Pergamon
2. Andrew Hinde., (1998), Demographic Methods
3. Barcley, G.W., (1958), Techniques of Population Analysis, Wiley
4. M. Nurul Islam., (2015), An Introduction to Demographic Techniques, 1st edition, Mullick & Brothers
5. Kpedekpo, G.M.K., (1982), Estimates of Demographic Analysis for Africa, Pub. Heinemann
6. Journals: Population Studies, Demography, Population and Development Review, Studies in Family Planning, Asia-Pacific Population Journals

Stat H-204: Economic Statistics **4 Credits**

Theory of firms: Firms technology, contrasts and similarities between firms and consume behavior analysis, Production function and its properties, returns to scale, productivity curves: total, average and marginal productivity curves along with their characteristics, stages of production, time horizons of decision making: short run, long run and very long run. Isoquants, marginal rate of technical substitution (MRTS), diminishing law of MRTS, output elasticity of inputs, Iso-cost lines, ridge lines, firm's optimization behavior: constrained output maximization, constrained cost minimization and profit maximization; producer's equilibrium, the expansion path, isoclines, Euler's theorem, linearly homogeneous production function. Cobb-Douglas (CD) production function with properties and estimation, constant elasticity of substitution production function.

Market mechanism: Market structure, perfect and imperfect competition, short- run and long-run equilibrium analysis in perfect competition.

Cost of production: Costs of production- fixed and variable, total and marginal costs, nature of cost, cost function and curves: short run and long run, diminishing return and short run costs, marginal average rule, long run cost curve as an envelope of short run cost curves, economics of scale of long run average cost, statistical studies of long run average cost curves, cost and profit functions with variable factor prices.

Pricing of the factors of production: Least-cost rule, Clark's theory, marginal productivity theory of income distribution, theories of wage, rent, interest and profit.

Distribution of income: Pareto and log-normal income distribution: properties, fitting, estimation of parameters, implications and limitations, concentration curve: Lorenze curve and equation, Gini's concentration ratio, Engel's law and curve, fitting of Engel's curve from family budget data.

National income: Concept of national income, money and functions of money, gross domestic product, gross national product, net national product, national income, personal income, disposable income, discretionary income, difference between discretionary income and disposable income, measurements of national income and problems, difficulties in the estimation of gross national product.

Index numbers: Definition and necessity of index numbers, problems in the construction of index numbers, different types of index numbers: simple and weighted indices, construction and problems, test of index numbers, cost of living index, constructions of different types of cost of living index, chain indices and its construction, base shifting, splicing and deflating of index numbers.

Text

Samuelson., (2009), P.A., Economics.19th edition, McGraw-Hill

References

1. Varian, H.R., (2010), Intermediate Microeconomics 8th edition. W.W. Norton & Company
2. Gupta and Kapoor., (2007), Applied Statistics. 4th edition, Sultan Chand & Sons
3. Davis., (1972), Economic Statistics. 2nd edition, Principia Press,
4. Parashar, S. and Singh., (2002), Econometrics and Mathematical Economics
5. Varinn, H.R., (1992), Microeconomic Theory, 3rd edition, Norton, W. W. & Company, Inc.
6. Henderson and Quandt., (1958), Microeconomic Theory. 3rd edition. McGraw-Hill
7. Wonnacott and Wonnacott., (1970), Econometrics, 5th edition, Wiley
8. Dominick Salvatore., (1992), Theory and Problems of Microeconomic Theory. McGraw-Hill
9. Croxton and Cowden., (1952) Practical Business Statistics, 2nd edition, Prentice-Hall, Inc.

Stat H-205: Operations Research **3 Credits**

Linear programming: Introductions: formulations of linear programming problems, graphical solutions of two variables problems, principal theorems of linear programming, simplex method, revised simplex method, dual simplex method, two-phase method, big-M method.

Game theory: Pure, mixed and optimal strategy, two-person zero sum game, relationship between two-person zero sum game and linear programming symmetric games.

Integer linear programming: Formulation of integer linear programming problem by cutting plane and branch and bound methods, solution of mixed integer, integer programming problem by cutting plane method.

Inventory models: Deterministic models, single item static model, single item static model with price breaks, multiple item static model with storage limitation.

Transportation problem: Basic feasible solution of transportation problem, optimality test, degeneracy, variations and least time transportation problem, trans-shipment problem, assignment problem.

Network models: Scope and definition, minimal spanning tree algorithm, shortest-route problem, maximal flow model.

Text

Taha, H.A., (1992), Operations Research: An Introduction, Coll-Macmillan International Editions. Macmillan Publishing Company

References

1. Dantzig. B., (1963), Linear Programming and Extension. Princeton University Press
2. Gass, S.I., (1961), Linear Programming, McGraw-Hill
3. Vajda, S., (2009), Mathematical Programming. Dover Publications Inc.
4. Hadly, G., (1978), Linear Programming, Addison Wesley
5. Hadly, G., (1963), Analysis of Inventory Systems, Prentice-Hall, International, N.Y.
6. Kohlas J., (1982), Stochastic Methods of Operations Research, Cambridge University Press
7. Gupta P. K. & Hira D. S., (1982), Problems in Operations Research, S. Chand
8. Duncan, A.J., (1986), Quality Control and Industrial Statistics. 5th edition
9. Dodge and Roming., (1941), Sampling Inspection Tables: Single and Double Sampling

Stat H-206: Ordinary Differential Equations **3 Credits**

Ordinary differential equation (ODE) of first order and first degree, singular solutions, separation of variable, homogeneous and non-homogeneous differential equations, exact differential equations.

Simple cases of differential equations of first order and of degree higher than one, linear differential equations with constant coefficient.

Applications of first order differential equations, higher order ordinary differential equations, ordinary simultaneous differential equations, equations reducible to homogeneous forms, homogeneous linear equations, orthogonal trajectories, partial differential equations: first order, second order and their analysis in details.

Text

Anton, H., (2000), Calculus with Analytic Geometry, Wiley, N.Y

References

1. Ayres, Franck: Theory and problems of differential equation
2. Ross, S.L., (1980): Introduction to ordinary differential equations, 4th edition. Wiley
3. Farid, S.M., Differential Equation & tensor Analysis
4. Durall and Robson, Alebra Vol. I, II, & III
5. Kuddus, D. A., Awal A. et., Ordinary differential equations

Stat H-207: Numerical Analysis and Advanced Calculus **3 Credits**

Group A: Numerical Mathematics

Differences of a polynomial, finite difference operators, interpolation and extrapolation by different formulae, inverse interpolation, numerical differentiation, numerical integration by different formulae, the accuracy of quadrature formula, numerical solution of equations by various methods, double interpolation.

Group B: Advanced Calculus

Beta and gamma function and their properties, incomplete beta and gamma function, Jacobian of transformation and their uses in statistics, Lagrange's multipliers and their uses in statistics, Fourier series: periodic function, Dirichlet conditions, odd and even functions.

Laplace transform: introduction, definition of integral transformation, definition of Laplace transform, Laplace transform of some elementary functions, sufficient conditions for the existence of Laplace transform, some important properties of Laplace transform, Laplace transforms of some special functions, inverse Laplace transform: definition, some important properties of the inverse Laplace transform; definition of the convolution, convolution theorem, application of Laplace transform.

Text

Agarwal, D., (2014), Advanced Integral Calculus. 19th edition, Krishna Prakashan Media

References

1. Mallick, S.A. and Uddin, M. A., (2007), Numerical mathematics
2. Burden, R.J and Faires, J. D., (2010), Numerical Analysis, 9th edition, Brooks Cole
3. Speigel, M.R., (1965), Schaum's outlines of Laplace Transform, McGraw-Hill
4. Wrede, R and Speigel M.R., (2010), Schaum's outlines of Advanced Calculus, 3rd edition, McGraw-Hill
5. Rahman, M.A., (2001), A College Mathematical Methods, second edition. Nahar Book Depot

Stat H 208: Real Analysis **3 Credits**

The real number system, axioms and completeness and its consequences; sets, compact sets, simple operation on them, cluster (limit) points, Bolzano-Weierstrass theorem.

Infinite sequences, convergence, theorems on limits, monotone sequences, subsequences, Cauchy sequences, Cauchy's general principle of convergence, Cauchy's first and second

theorems on limits, infinite series of real numbers, convergence, and absolute convergence, tests for convergence.

Continuity, continuous functions, uniform continuity, intermediate value theorem, mean value theorem, Taylor expansion.

Metric and topological spaces; limit points; open and closed sets; interior and exterior points; boundary points; Continuous mapping and Cauchy sequences.

Riemann-Steiljes integrals via Riemann's sums and Darboux's sums, necessary and sufficient conditions for integrability.

Measure and integrals on abstract sets on real lines, Cramer measurability: fundamental definitions, auxiliary lemma; fundamental theorems; measurable functions; Lebesgue measure on a real line, plane, distinction between probability measure and Lebesque measure and Lebesque integrals.

Applications in Statistics.

Text

Bartle, R. G., and Sherbert, D. R., (2000). Introduction to real analysis, 4th edition. John Wiley & Sons, New York

References

1. Royden, H.L., (2010), Real Analysis, 4th edition, China Machine Press
2. Rudin, W., (1976), Principles of Mathematical Analysis. McGraw-Hill
3. Simmons, G.F., (1963), Introduction to Topology & Modern Analysis, McGraw-Hill, N.Y.
4. Berherion S.K., (2007), Introduction to Measure & Integration. Springer
5. Schaum Series., (1963), Advanced Calculus & Real Analysis. McGraw-Hill
6. Sipschute, S., General Topology, McGraw-Hill, N.Y.
7. Halmos,P.R., (1969), Measure Theory, Springer
8. Billingeley, P., (1995), Probabability and Measure, 3rd edition. Wiley, N.Y.
9. Kingman, J.F.G., (1966), Measure and Probability, CUP
10. Pitt, H.R., (1965), Integration measure and Probability, Oliver and Boyed
11. William, F.T., (2011), Introduction to Real Analysis, Peason Publication, USA

Stat H-209: Computing III (Programming with R) 2 Credits

Introduction: The R language, R and the window system, downloading R, installing R.

Using R: A simple R session with some basic R commands, case-sensitivity, recall and correction of previous commands, assignments and expressions, simple manipulations of

numbers, getting help with existing R functions and features, executing commands from a file, diverting output to a file.

Vectors: Generating regular sequences, creating vectors, vector arithmetic, logical vectors, character vectors, missing values, selecting and modifying subsets of a vector, combining elements of two vectors.

Objects: Class of an object, modes and their attributes.

Matrices: Creating matrices, different operations of matrices, selecting and modifying subsets of a matrix, linear equations and inversions of matrices, eigen values and eigen vectors, combining rows (cases) and columns (variables) of two matrices.

List and data frames: Making list and data frames, attaching and detaching data frames.

Control statements in R: Conditional execution with if statement, repetitive execution with for, repeat and while.

Writing new R functions: Simple examples, arguments and defaults, assignments within functions, returning multiple objects as output.

Importing data in R: Reading text files with read.table and scan functions, importing data from other systems like SAS, SPSS, S-Plus, Excel, STATA, editing data.

Statistical analyses: Basic statistical techniques, correlation and regression, estimation of parameters of multiple regression model, inference in multiple regression, partial correlation, multiple correlation and related tests.

Probability distribution: R names for different distributions, obtaining densities, cumulative probabilities, quantiles and random samples from different distributions

Numerical mathematics: Numerical integration and solution of equations, Newton-Raphson method

Text

Venables, W.N. and Smith, D.M., (2016), An Introduction to R. Springer

References

1. Crawley, M.J., (2009), The R book. John Wiley & Sons, West Sussex
2. Curran, J.M., (2011), Introduction to Data Analysis with R for Forensic Scientists. CRC press, Boca Raton

Stat H-210: Computing IV (Introduction to Demography; Economic Statistics) 2 Credits

Introduction to Demography

Age-sex composition, population pyramid, population growth rate, calculations of various rates and ratios of fertility and mortality, direct and indirect standardization of rates and ratios, estimation of singulate mean age at marriage, migration etc.

Economic Statistics

Fitting of demand curve and interpretation, fitting of the Cobb-Douglas production function, fitting income distribution: Pareto and log-normal, finding of Gini's ratio, fitting of Lorenze and Engel's function, construction of different types of index numbers, test of index numbers, cost of living index, construction of chain indices, splicing and deflating of index numbers.

References

See the references for **Stat H-203** and **Stat H-204**.

Stat H-211: Viva Voce 2 Credits

Detailed Syllabus: Third Year

Stat H-301: Test of Hypothesis **4 Credits**

Preliminaries of tests: Hypothesis, simple and composite hypotheses, null and alternative hypotheses, concept of test of significance, procedures of a test, errors in testing hypothesis, level of significance, power of a test, one-tailed and two-tailed tests, p-value.

Common tests of hypothesis: Testing the significance of single mean, single variance, single proportion, difference of two means and proportions, ratio of two variances, simple correlation coefficient and regression coefficient for single and double sample. Paired t-test, testing the homogeneity of several population means, variances and proportions, statement about p-values for these tests.

Association of attributes: Association & disassociation, measure of association, contingency tables, general test of independence in an $r \times c$ contingency table, Fisher's exact test for a 2x2 contingency table, test of goodness of fit.

Evaluation of tests: Power function, best critical region, most powerful test, unbiased test, Neyman-Pearson lemma, uniformly most powerful test, monotone likelihood ratio test, a decision theoretic view of hypothesis testing.

Likelihood ratio test: Introduction and distribution of likelihood ratio, properties, tests for single, double and several means, variances, regression and correlation coefficients.

Sequential probability ratio test: Introduction, SPRT, determination of constants, operating characteristic function, average sample number, graphical procedure, truncation of SPRT.

Non-parametric tests: Concepts of non-parametric tests, useful non-parametric tests like sign test, rank test, run test, signed rank test, median test, Kolmogorov-Smirnov test of goodness of fit, Kruskal Wallis test, Cochran's test, stratified rank sum test, Friedman test and Spearman rank correlation test.

Text

Mood, Graybill and Boes, (1974), Introduction to the Theory of Statistics, 3rd edition, McGraw-Hill

References

Snedecor., (1989), Statistical Methods. 8th edition. Wiley-Blachwell

1.
2. Mendenhall, (2007), Mathematical Statistics 7th edition, Duxbury Press
3. Anderson, R.L. and Bancorft, T.A., (1952) Statistical Theory in Research. McGraw-Hill
4. Ali, A., (1969), Theory of Statistics, Vol. 2. Dacca Book Mart, Banglabazar
5. Hogg, R.V. and Craig, A.T., (1959), An Introduction to Mathematical Statistics, McMillan-Collierm, N.Y.
6. Hoel, P.G., (1965), Introduction to Mathematical Statistics, 7th edition, Wiley, N.Y.

7. Rao, C.R., (1965), Linear Statistical Inference & its applications, 2nd edition, Wiley
8. Cox, D.R. and Hinkley, U., (1974), The Theory of Statistics, Methuen,London
9. Kendall and Stuart., (2008), The Advanced Theory of Statistics, 6th edition, Vol. I & II

Stat H-302: Sampling Techniques **3 Credits**

Simple random sampling: Estimates of population characteristics and standard errors. Sampling for proportions, randomization theory results for simple random sampling, a model for simple random sampling situations where a simple random sample is appropriate.

Systematic sampling: Estimation of population characteristics, systematic sampling in some special populations.

Stratified sampling: Definition and basic ideas, theory of stratified sampling, allocating observations to strata, defining strata, a model for stratified sampling, post-stratification, stratified versus quota sampling.

Ratio and regression estimation: Use of auxiliary data in ratio estimation, regression estimation, regression models, design implications of regression models, comparison of ratio and regression estimation method.

Cluster sampling: Notation for cluster sampling, one-stage cluster sampling, designing a cluster sample, models for cluster sampling, comparison with simple random sampling and systematic sampling, determination of optimum cluster size, stratified cluster sampling.

Simple cluster sampling with unequal sized cluster-estimates, bias, standard error and efficiency.

Sampling of unequal clusters with unequal probability with replacement, the Horvitz-Thompson estimator and its properties, the Hansen-Hurwitz estimator and its properties, selection of samples with probability proportional to size (PPS) with replacement- use, application, estimate and standard error.

Sampling of unequal clusters with unequal probability without replacement- different selection methods: Brewer's, Durbin's, Sampford's, PPS systematic, Raj's, Murthy's and Rao-Hartley-Cochran methods of selection; detailed study on the related formulae, estimates, variances, estimates of variances for these methods.

Sample size: Concepts of sample size estimation, determination of sample size for estimating mean and proportions, design effect, sample size for comparison of two means or proportions.

Text

Lohr, S.L., (2005), Sampling Design and Analysis, Brooks/Cole

References

10. Cochran, W.G., (1977), Sampling Techniques, 3rd edition, Wiley
11. Islam, M.N., (2008), An Introduction to Sampling Methods, Book World
12. Levy, P.S. and Lemeshow, S., (1999), Sampling of Populations, 3rd edition, Wiley
13. Kish, L., (1965), Survey Sampling, Wiley

14. Singh, D and Chaudhury, F.S., (1987) Theory and Analysis of Sample Survey design. John Wiley & Sons Inc
15. Mendelhall, Ott, and Scaeffer., (1995), Elementary Survey Sampling, 5th edition, pub. Cengage Learning
16. Sukhatme, P.V., (1970), Sampling theory of Surveys with Application, 2nd edition, Asia Publishing House, London
17. Yates, F., (1981), Sampling Methods for Censuses and Surveys. 4th edition, Hodder Arnold; Enlarged

Stat H-303: **Regression Analysis** **4 Credits**

Fitting a straight line by least squares: Linear relationship between two variables, linear regression: fitting a straight line by least squares, the analysis of variance, confidence intervals and tests for β_0 and β_1, test for significance of regression.

Checking the straight line fit: Lack of fit and pure error, testing homogeneity of pure error, examining residuals: the basic plots, non-normality checks of residuals, checks for time effects, non-constant variance, need for transformation and curvature, other residual plots.

Simple linear regression in matrix notation: Fitting a straight line in matrix terms, singularity, the analysis of variance in matrix terms, the variances and covariance of b_0 and b_1 from matrix calculation, variance of $\hat{Y}$ using the matrix development, summary of matrix approach to fitting a straight line (nonsingular case).

Multiple linear regression: Model fitting, least squares properties, confidence interval versus regions.

Extra sums of squares and tests: The "extra sum of squares" principle, two predictor variables: example, partial and sequential F tests.

More on checking fitted models: The hat matrix H and the various types of residuals, detection of influential observations: Cook's statistics, other statistics measuring influence.

Multiple regression- special topics: Generalized least squares and weighted least squares: examples, restricted least squares, inverse regression (multiple predictor case).

Transformation of independent variables: Polynomial regression fitting, splines.

Transformation of the response variable: Introduction and preliminary remarks, power family of transformations on the response, Box-Cox method, transformations chosen to stabilize variance.

Indicator/dummy variable: Indicator variables versus regression on allocated codes, dummy variables to separate blocks of data with different intercepts same model, interaction terms involving dummy variables, dummy variables for segmented models.

Selecting the "best" regression equation: All possible regressions and "best subset" regression, stepwise regression, backward elimination, significance levels for selection procedures.

Ridge regression: Introduction, basic form of ridge regression, circumstances when ridge regression is reasonable, use of ridge regression in model selection.

Orthogonal polynomials: Introduction, model fitting, properties.

Text

Draper, N.R. and Smith, H., (1998), Applied linear regression (3rd edition), Wiley, N.Y.

References

1. Ryan, T.P., (1997), Modern Regression Methods, Wiley, N.Y.
2. Graybill, P., (1961), An introduction to linear statistical models, Vol. 1 McGraw-Hill, N.Y.
3. Montgomery, D.C. and Peck, E., (2012), An introduction to Regression analysis, 5th edition. Wiley, N.Y.

Stat H-304: Epidemiology **4 Credits**

Epidemiologic concepts: Definition and scope of epidemiology, key issues in epidemiology, health and disease, sources of data on community health, vital statistics and morbidity data, descriptive epidemiology: person, place, time; analytic epidemiology: causality.

Types of epidemiologic research: Experimental (laboratory, clinical trial, and community intervention), quasi experimental (clinical/laboratory, program/policy), observational studies: design options in observational studies – methods of observations; typology of observational study designs (cohort, case-control, and cross-sectional studies).

Measures of disease frequency: Incidence and prevalence, basic measures of incidence and prevalence, mortality measures, age, period and cohort effects.

Measures of association: Ratio measures and difference measures (relative risk, odds ratio, risk difference etc.), comparison of proportions from different samples, standard error of estimators, test of hypotheses.

Measures of potential impact: Etiologic fractions, prevented fractions.

Diagnostic testing: Positive and negative predictive values, false positive and false negative, sensitivity and specificity.

Validity: Validity and precision, direction of bias, sources of bias, selection bias, information bias, misclassification bias.

Stratified analysis: Test for overall association, Mantel-Haenszel estimator and test, confounding, criteria and test for confounding (single factor confounding).

Matching: Definition of matching, types of matching schemes, r-to-1 matching, comparison of m matched samples, Mcnemar test.

Interaction, effect modification and synergism: Statistical interaction and effect modification, additive and multiplicative models, interaction assessment via regression analysis.

Text

Jewel, N.P., (2004), Statistics for Epidemiology, 3rd edition, Chapman & Hall/Crc.

References

1. Kahn, H.A. and Sempos, C.T., (1989), Statistical Methods in Epidemiology (Monographs in Epidemiology and Biostatistics, Vol. 12) (Paperback), Oxford University Press, New York
2. H Rothman, K.J. and Greenland, S., (1998), Modern Epidemiology, Lippincot-Raven, Philadelphia
3. Fleiss, J.L., (1981), Statistical Methods for Rates and Proportions, 2nd edition, Wiley, New York. Greenberg, R.S. et al.

Stat H-305: Industrial Statistics and Official Statistics 2 Credits

Elementary concepts of industrial statistics: Nature, scope and sources of industrial statistics, study of different types of industrial statistics: production and realization statistics, input-output statistics, labor statistics and working time, production cost statistics, wage statistics, wastage statistics, etc., productivity of labor, utilization of labor resources, identification of quality level, quality and its relation to product.

Statistical quality control: Importance of statistical quality control in industry, statistical quality control techniques, its uses and usefulness, product control and process control, assignable and non-assignable sources of variation, basic concepts of control charts, principles and statistical basis of control chart, 3-sigma control limits, construction and interpretation of control charts (variable and attribute), criteria for detecting lack of control, natural tolerance and specification limits, sampling inspection and its usage, acceptance sampling: single and double sampling plans by attributes, expressions for consumers' risk and producers' risk for single and double sampling plans, OC and ASN curves and their application.

Official statistics: Sources, critical evaluation of the sources of official statistics, limitations and recommendations, methodological issues, some national and international statistical publications, specific examples from BBS, planning, commission, Bangladesh bank, etc.

Text

Duncan, A.J., (1952), Quality control and Industrial Statistics, 5th edition, Richard D. Irwin, Inc

References

1. Montgomery, D.C., (2009), Introduction to Statistical Quality Control, 7th edition, Wiley
2. Dodge and Roming., (1998), Sampling inspection tables: Single and Double Sampling, 2nd revised edition, Wiley
3. Grant, E.L., (1996), Statistics Quality Control. 6th edition, Wiley
4. Croxton and Cowden (1969), Practical Business Statistics. 4th edition, Asia Publishing House.
5. Wessel, Wellet and Simons., (2016), Statistics as applied to Economics and Business, Springer International Publishing
6. Wetherill, G.B., (1977), Sampling Inspection and Q.C. Chapman & Hill.
7. Gupta and Kapur., (1994), Applied Statistics. 3rd reprint edition, Sultan Chand & Sons, BBS publications

Stat H-306: Mathematical Demography and Actuarial Statistics 3 Credits

Errors in demographic data: Types and sources of errors in demographic data, methods of evaluation and detection of errors in demographic data, graduation of data, dual record system, Chandrasekaran-Deming method, census coverage and method of checking completeness of coverage.

Standardization of demographic measures: Direct and indirect method of standardization.

Life table: Definition, use and functions of life tables, different types of life table, construction of life tables, actuarial life table, force of mortality and related problems.

Population models: Stable, quasi-stable and stationary population model, fertility, mortality and age structure in stable populations, Lotka and Dublen's model.

Nuptiality: Nuptiality models, nuptiality table, nuptiality pattern in Bangladesh.

Population projection: Population estimates and projections, mathematical methods, component method of population projection.

Actuarial statistics: The meaning of actuarial science, role of insurance in the economy, role of an actuary.

Economics of insurance: Utility theory, insurance and utility, elements of insurance, optimal insurance.

Individual short-term risk models: Models for individual claims, approximations for the distributions of sum of claims, applications to insurance.

Text

Swanson, D. A. and Siegel, J.S., (2004). The Methods and Materials of Demography. 2nd Edition. Emerald Group Publishing Limited

References

1. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J., (1997), Actuarial Mathematics
2. Specigelman., (1955), Introduction to Demography. Chicago, Ill. : Society of Actuaries
3. Pollard, A.H., Farhat, Y. & Pollard, G.N., (1990), Demographic Technique. 3rd edition, Pergamon Press
4. Namboodiri, M.K. & Suchindran, C.M., (1987), Life Table Techniques and their Applications, Academic Press, London
5. Andrew Hinde., (1998), Demographic methods, Arnold Publisher
6. Barcley, G.W., (1998), Techniques of Population Analysis. Wiley & Sons Inc.
7. Kellison, S.G. (1991), The Theory of Interests, 2nd edition, McGraw-Hill/Irwin
8. Kpedekpo, G.M.K., (1982), Estimates of Demographic Analysis for Africa. pub. Heinemann
9. Chiang, C. L., (1984), The Life Table and its Application. Original edition, Krieger Publishing Company; United Nations: Manuals I to XI
10. Bathen, R.W., (1978), Mortality Table Construction. Prentice-Hall
11. Pressat, R., Word Book in Demography (Latest edition), Nethuen, London

Stat H-307: Simulation **3 Credits**

Introductory examples of simulation, estimation, and graphics: Simulating random samples from finite populations, coverage probabilities of binomial confidence intervals.

Generators: Introductory comments on random numbers, linear congruential generators, validating desirable properties of a generator, transformations of uniform random variables.

Generating random samples: Transformations involving normal random variables using box-muller method, Marsaglia method, direct method, indirect method, accept/reject algorithm, generating data from different distributions such as binomial, Poisson, exponential, gamma, beta etc.

Monte Carlo methods: Buffon's needle experiment, Monte Carlo integration and limit theorems, law of large numbers, central limit theorem.

Variance reduction techniques: Antithetic sampling, stratified sampling, importance sampling and control variates methods.

Screening tests: Prevalence, sensitivity, and specificity, estimation of prevalence, predictive values, Bayes' theorem for events.

Metropolis algorithm: The Metropolis algorithm, mathematical formulation and Hastings's generalization, some special algorithms such as random-walk metropolis, metropolized independence sampler, configurational bias Monte Carlo.

Markov chains and Gibbs sampler: The Markov property, transition matrices, limiting behavior of a 2–state chain, idea of the Gibbs sampler, a simple Gibbs sampler, Gibbs sampling algorithm with illustrative examples.

Text

Suess, E.A. and Trumbo, B.E. (2010). Introduction to Probability Simulation and Gibbs Sampling with R. Springer, New York

References

1. Ross, S. M., (2012). Simulation, 5th edition, Academic Press, London
2. Casella, G. and Berger, R.I., (2002). Statistical Inference, 2nd edition, Duxbury press, CA
3. Dunn, W.L. and Shultis, J.K., (2012). Exploring Monte Carlo Methods. Elsevier, Oxford
4. Glasserman, P., (2004). Monte Carlo Methods in Financial Engineering. Springer, New York
5. Jones, O., Maillardet, R., and Robinson, A., (2009). Introduction to Scientific Programming and simulation using R. Chapman & Hall/CRC, London
6. Liu, J.S., (2001). Monte Carlo Strategies in Scientific Computing. Springer, New York
7. Ross, S.M., (2007). Introduction to Probability Models, 9th edition, Elsevier, Oxford

Stat H-308: Introduction to Big Data **2 Credits**

The development and challenges of Big Data, definition and features of Big Data, difference between Big Data and ordinary data, importance of making decision based on Big Data.

Introduction to distributed databases, Apache Cassandra for distributed database management, MongoDB for NoSQL data storage, data warehousing and business intelligence, introduction to Apache Flink, data lakes and their role in Big Data, cloud computing, relationship between cloud computing and Big data, IoT, relationship between IoT and Big Data, data center, Hadoop, relationship between Hadoop and Big Data, Apache Spark fundamentals, Spark RDDs (Resilient Distributed Datasets), Spark SQL and data frames, machine learning with Apache Spark.

Introduction to Spark MLlib, Spark streaming for real-time data processing, deep learning frameworks for Big Data (TensorFlow, PyTorch, Keras), transfer learning and fine-tuning on large datasets, Apache NiFi for data integration, Apache Airflow for workflow management.

Text

Chen, M., Mao, S., Zhang, Y., & Leung, V.C.M., (2014). Big Data: Related Technologies, Challenges and Future Prospects, Springer

Reference

Hrushikesha. M., Prachet. B., and Deepak. C., (2015). Big Data: A Primer, Springer

Stat H-309: Research Methodology **3 Credits**

Research and methods: Meaning of research, investigation, research and scientific methods, research methods versus research methodology, categories of research, characteristics of a good research, research paradigm, and basic terminologies in research.

Ethics in research: Meaning of ethics, ethics and privacy application form, participant information and consent form, conflict of interest and other ethical issues, declaration of researchers.

Research process: Concept of research process, problem, selection of research problem, review of literature, objectives of the study, research question, research hypothesis and illustrative examples.

Research design: Types of research design - case studies, trend and panel studies, experimental design, non-experimental design, cross-sectional and quasi-experimental design etc., sampling design and sample size determination.

Questionnaire design process: Meaning of questionnaire, types of questions, question formulation and wording, questionnaire sequence, questionnaire designing process, examples of a questionnaire.

Data and data collection techniques: Concept of data and big data, primary and secondary sources of data, different methods to collect data: mail-questionnaire, personal interview, telephone interview; principles of interviewing. Qualitative data collection: Observations, key informants interview (KII), in-depth interview, focus group discussion (FGD), participatory rural appraisal (PRA), rapid appraisal technique (RAT), Delphi technique.

Measurement of reliability and validity of data: Classical theory of reliability, reliability coefficient, extension of classical theory, test-retest method, parallel forms technique, split-half method, content validity, empirical validity, construct validity, validity threats.

Research proposal writing: Research proposal for academic degree, criteria for evaluating research proposal, teaching/research assistantship, research proposal for professional purpose, format of technical and financial proposal, concept of TOR, EOI, RFP, PDS, DPP, EIA and SIA.

Research report writing: Acknowledgements, abstract, table of contents, introduction, literature review, materials and methods, results and discussions, conclusions and

recommendations, bibliographies and quotation, standard citation styles, references, appendices.

Research communication: General format for a term paper, innovating a scientific paper: guide for contributors, preparing manuscript for book publication, oral presentation, copyright, plagiarism etc.

Monitoring and evaluation: Objectives of monitoring and evaluation, monitoring and evaluation process, designing a monitoring and evaluation system, program performance indicators, writing an evaluation report.

Text

Akanda, M. A. S. (2018), Research Methodology: A Complete Direction for Learners, 3rd Edition, Akanda & Sons Publication, Dhaka

References

1. Neuman, W.L., (2000), Social Research Methods: Qualitative and Quantitative Approaches, 4th edition, Allyn and Bacon, Boston
2. Frankfort, J., (2014), Research Methodology. 8th edition, Worth Publishers
3. Kothari, C.R., (1995), Research Methodology, 2nd edition, New Age International Publishers
4. Bailey., (1992), Social Research Methods. 4th edition, Broock/Cole
5. Krisaaswami and Raaganatham., (2005), Methodology of research in social sciences, 2nd edition, Himalaya Publishing House
6. Das, A. Social survey and research
7. Sufian, A.J.M., (1998), Methods and techniques of social research. The university press
8. Rao, C.R., (1952), Applied Statistical Methods in Biometric Research
9. Palmor, J.O., (1987), Statistical Methods in Research, Cambridge
10. Kish, L., (1995), Survey Methods in Social Investigation. John & Wiley sons
11. Islam, M.N., (2011), An introduction to Research Methods, 3rd edition, Book World

Stat H-310: Computing V (SPSS and SAS) **2 Credits**

SPSS

Data and data file: Defining the variable, variable type, variable name, variable formats, variable labels, value labels, data entry program, data cleaning, range check, logical (consistency check) etc.; definition and operations with date variable, different types of SPSS files.

Data management: Inserting variables and cases, merging and splitting files, recoding, conditional transformation: temporary selection, permanent selection; selection of a random sample, construction of working file.

Classification and presentation: Data classification and tabulation, construction of frequency distribution table, cross table, graphical representation of data, exploratory data analysis: stem and leaf plots, box plot.

Computing descriptive statistics: Central tendency, dispersion, skewness and kurtosis.

Hypothesis testing and regression analysis: Test of hypothesis, Chi-square test: independence of attributes and goodness of fit, analysis of variance (ANOVA), correlation, simple and multiple linear regression.

SAS

Overview: SAS data step, syntax of SAS procedures, comment statements, creating and reading data sets, data in the program itself, reading external files, writing data to an external file; data cleaning.

Data management: Inserting variables and cases, merging and splitting files, recoding, conditional transformation: temporary selection, permanent selection; selection of a random sample, construction of working file.

Classification and presentation: Data classification and tabulation, construction of frequency distribution table, cross table, graphical representation of data, exploratory data analysis: stem and leaf plots, box plot.

Computing descriptive statistics: Central tendency, dispersion, skewness and kurtosis.

Hypothesis testing and regression analysis: Test of hypothesis, Chi-square test: independence of attributes and goodness of fit, analysis of variance (ANOVA), correlation, simple and multiple linear regression.

References

1. Field, A. (2009). Discovering Statistics using SPSS, 3rd edition, SAGE, London
2. Cody, RP and Smith, J K, (2005). Applied Statistics and the SAS programming language, 5th edition, Prentice Hall

Stat H-311: Computing VI (STATA) 2 Credits

Overview and data management: An example of STATA, searching for information, example commands, creating and reading data set, specifying subsets of the data: in and if qualifiers, drop and keep functions; generating and replacing variables, converting continuous to categorical variables, numeric and string formats; creating dummy variables, recoding variables, missing value codes, sorting data, combining two or more STATA files, collapsing

data, reshaping data, creating random data and random samples, writing programs for data management.

Classification and presentation: Data classification and tabulation, frequency distribution, cross table, graphical representation of data, non-linear transformations of data.

Computing descriptive statistics: Measures of central tendency, measures of dispersion/variation, shape characteristics of a distribution, using frequency weights, standard error.

Hypothesis testing and regression analysis: Test of hypothesis and test of independence, analysis of variance (ANOVA), correlation, simple and multiple linear regression, logistic regression, predicted values and residuals, diagnosing autocorrelation, multicollinearity and heteroskedasticity.

Analysis of survey data: Design weights, post-stratification weights, survey-weighted tables and graphs, bar charts for multiple comparisons.

References

1. Hamilton, L. C. (2006). Statistics with STATA. Thomson Brooks/Cole
2. Rabe-Hesketh, S and Everitt, BS (2007). A handbook of statistical analysis using Stata. 4th edition, Chapman Hall/CRC

Stat H-312: Computing VII (Regression Analysis; Mathematical Demography and Actuarial Statistics) 2 Credits

Regression Analysis

Estimation of parameters of multiple regression model, inference in multiple regression model (test of significance of the overall regression, testing general linear hypothesis, test and confidence interval for individual parameters), partial correlation, multiple correlation and related test, model selection, fitting polynomial regression, orthogonal polynomials, etc., examination of residual, outliers.

Mathematical Demography and Actuarial Statistics

Errors in demographic data, detection of errors in demographic data, graduation of data.

Standardization of demographic measures: direct and indirect method of standardization.

Life table: life table construction, force of mortality and related problems; population models: stable, quasi-stable and stationary population model; construction of actuarial life table and its application.

Economics of insurance, elements of insurance.

Reference

See the references for **Stat H-303** and **Stat H-306**.

Stat H-313: Viva Voce **2 Credits**

Detailed Syllabus: Fourth Year

Stat H-401: Multivariate Analysis **3 Credits**

Introduction: Ideas of multivariate data, applications of multivariate techniques.

Multivariate distributions: Multinomial distribution with properties, multivariate normal distribution (MND) with properties, derivation of multiple and partial correlation coefficients, estimation of parameters, Wishart distribution, Hotelling T^2 distribution, Mahalanobis D^2, generalised variance.

Distribution of quadratic forms: Quadratic forms and their central and non-central distributions; expectations, variances and co-variances of quadratic forms; independence of two or more quadratic forms.

Inference about a mean vector: Introduction, the plausibility of μ_0 as a value for a normal population mean, likelihood ratio tests, confidence regions and simultaneous comparisons of component means, large sample inferences about a population mean vector, inferences about mean vectors when some observations are missing.

Comparisons of several multivariate means: Introduction, paired comparison and a repeated measures design, comparing mean vectors from two populations, comparing several multivariate population means (one-way MANOVA), simultaneous confidence intervals for treatments effects, two-way multivariate analysis of variance, profile analysis, repeated measures designs and growth curves.

Multivariate linear regression models: Introduction, the classical linear regression model, least squares estimation, inferences about the regression model, multivariate multiple regression.

Text

Anderson, T.W., (1984), Introduction of Multivariate Statistical Analysis, 2nd edition, John Wiley

References

1. Johnson, R.A. & Wichern, D.W., (1982), Applied Multivariate Analysis, Prentice- Hall Inc., Englewood Cliffs, NJ
2. Morrison, D.P., (1976), Multivariate Statistical Methods, 4th edition McGraw-Hill
3. Bhuiyan, K.C., (2006), Multivariate Analysis and its Applications. New Central Book Agency
4. Kleinbaum, D.G., Kupper and Muller, K.E., (1998), Applied Regression Analysis and other Multivariate Methods, 3rd edition, Duxburg Press, Pacific Grove

5. Maardia, K.V., Kent, S.T. and Bibly, J.M., (1979), Multivariate Analysis, Academic Press, London
6. Johnson, N.L. and Kotz, S., (1969), Continuous Multivariate Distributions, John Wiley
7. Kshiragar, A.M., (1972), Multivariate Analysis, Marcel Dekker
8. K V Mardia, J T Kent and J Bibby., (1979), Multivariate Analysis, Academic Press

Stat H-402: Time Series Modeling **3 Credits**

Fundamental concepts: Stochastic processes, the autocovariance and autocorrelation function (ACF), the partial autocorrelation function (PACF), sample mean, sample autocovariance, sample ACF, sample PACF, moving average (MA) and autoregressive (AR) representation of time series processes, linear difference equation.

Stationary time series models: Autoregressive processes: 1st order autoregressive AR(1) process, 2nd order autoregressive AR(2) process, the general p-th order autoregressive AR(p) process.

Moving average processes: 1st order moving average MA(1) process, 2nd order moving average MA(2) process, the general q-th order moving average MA(q) process, the dual relationship between AR(p) and MA(q) processes, the general autoregressive moving average ARMA (p, q) process, the ARMA(1, 1) process.

Nonstationary time series models: Non-stationarity in the mean: deterministic trend models, stochastic trend models and differencing, classical decomposition method.

Autoregressive integrated moving average (ARIMA) models: The general ARIMA model, the random walk model, the ARIMA (0, 1, 1) or IMA (1, 1) model.

Non-stationarity in the variance and the autocovariance: variance and autocovariance of the ARIMA models, variance stabilizing transformations.

Forecasting: Minimum mean square error (MSE) forecasts: minimum MSE forecasts for ARMA models, minimum MSE forecasts for ARIMA models, computation of forecasts, the ARIMA forecast as a weighted average of previous observations, updating forecasts, eventual forecast functions.

Model identification: Steps for model identification.

Parameter estimation, diagnostic checking and model selection: The method of moments, maximum likelihood method, and ordinary least squares (OLS) estimation in time series analysis, diagnostic checking, model selection criteria.

Seasonal time series models: Traditional methods (regression method, moving average method), seasonal ARIMA models.

Testing for a unit root: Testing for a unit root in the autoregressive, seasonal time series, or other models.

Text

William W. S. Wei., (2005), Time Series Analysis Unvaried and Multivariate Methods, second edition, Pearson

References

1. Gwilym M. Jenkins & Gregory C. Reinsel., (1970), Time Series Analysis Forecasting and Control, 4th edition, George E.P. Box, Wiley
2. Robert H. Shumway and David S. Stoffer., (2017), Time Series Analysis and Its Applications with R Examples, 4th edition, Springer
3. Jonathan D. Cryerand Kung-Sik Chan., (2008), Time Series Analysis with Applications in R, 2nd edition, Springer

Stat H-403: Design and Analysis of Experiment **4 Credits**

Definition of ANOVA, basic assumption of ANOVA, basic terminology of ANOVA, related concepts of experimental design and sample design.

Theory of ANCOVA and its application.

Basic concepts of experiments and designing: Experiment and its types, steps involved in experiment, design of experiments, its purposes, basic principles of experimental designs, their purposes, Fisher's diagram, etc.

Experimental units: Definition, different types: agricultural plots, block, examples in other areas, reasons of blocking, uniformity trials and fertility control mapping, choice of size and shape of plots and blocks, Smith's variance law and other field plot techniques, experimental error and sampling error, sources of experimental error and controlling measures.

Basic experimental designs: Completely randomised design (CRD), Randomized block design (RBD), Latin square design (LSD), Graeco LSD, Multiple LSD etc., their definitions and layouts, relative merits, demerits, model adequacy checking, orthogonality and relative efficiency, etc.

Multiple comparison: Grouping of treatments, necessity, different methods: Fisher's least significant method, Duncan's multiple range test, Student-Newmen-Keul's test, Tukey's test, Scheffe's method, etc.

Missing plot techniques: Orthogonality and non-orthogonality problems, effects of missing values in basic designs, methods of estimation for missing values, and their standard error, LS method, iterative method etc., adjustment in analysis procedures, comparison of pair treatments in missing plots etc.

Factorial experiments: Basic ideas of variety trials, factorial experiment, Bio-assays, etc., linear contracts, orthogonal contrasts, different factorial experiments: 2^k , etc., simple-effects, main-effects and interactions and analysis procedures: contrast method, Yates algorithm, confounding in factorial experiments: definitions, necessity, different types of confounding and their analysis; asymmetric factorial experiments 2×3, 2×4, 3×4, etc.

Experiments with random factors: The random effect model, two-factor factorial experiments with random factors, Two-factor mixed model etc.

Text

Montgomery, D.C. (2003), Design and Analysis of Experiments, 5th edition, Wiley, N.Y.

References

1. M.R. Bhuiyan (2007), Fundamentals of Experimental Design, 2nd edition
2. Cochran & Cox (1952), Experimental Design, Wiley, N.Y.
3. Kempthrone, (2008), Design and Analysis of Experiments, 2nd edition, Wiley, N.Y.
4. Yates, F., (1978), Design and Analysis of Factorial Experiments, Harpenden, Herts, England.
5. Searle, S.R., (2016), Linear Models. 2nd edition, Wiley
6. John, U.A. & Quenouille, M.H., (1953), Design & Analysis of Experiments, Charles Griffin & Co.
7. Steel and Torrie (1982), Principle and Procedures of Statistics. McGraw-Hill
8. Cox, D.R., (1992), Planning of Experiments. Advanced Edi. Wiley
9. K.C. Bhuiyan, (2001), Experimental Design and Analysis of Variance, Vol.1 & 2, Bangla Academy
10. Das, M.N. and Giri, N.C., (1979), Design and Analysis of Experiments. Wiley

Stat H-404: Econometrics **4 Credits**

Concepts: Definition of Econometrics, scope, role, nature of the Econometrics, difference with mathematical economics and economic statistics.

Measures of model adequacy: Concept and residual analysis.

Model misspecification: Basic concepts and consequences, omission of relevant variables, inclusion of irrelevant variables and measurement errors.

Regression with qualitative dependent variable: Linear probability model, logit model, probit model and tobit model.

Generalized least squares (GLS): The GLS estimator and the properties of GLS estimator, spherical and nonspherical disturbances.

Multicollinearity: Basic concepts, reasons, consequences, detection and remedial measures.

Autocorrelation: Basic concepts, reasons, consequences, detection and remedial measures.

Heteroscedasticity: Basic concepts, reasons, consequences, detection and remedial measures.

Simultaneous equation models: Basic concepts, endogenous variable, exogenous variable and predetermined variables, structural model and reduced-form model, simultaneous equation model, simultaneous equation bias, estimation of simultaneous equation models: method of indirect least-squares (ILS) and two-stage least-squares (2SLS).

Identification: Concepts and methods of identification.

Non-linear regression models: Definition of intrinsically linear and intrinsically non-linear regression models, estimation of linear and nonlinear regression models, the trial and error method, different approaches to estimating nonlinear regression models.

Dummy variable regression models: Basic concepts, ANOVA models and interpretation, caution in the use of dummy variables, the ANCOVA models, structural change, structural break, CHOW test.

Time series econometrics: Basic concepts, the unit root test, Dickey Fuller test and Augmented Dickey fuller test, cointegration, spurious regression, forecasting approaches in econometrics.

Text

Gujarati, D.N., (2003), Basic Econometrics. 5th edition, McGraw-Hill

References

1. Draper, N.R, and Smith, H., (1998), Applied Linear Regression, 3rd edition, Wiley, N.Y.
2. Wallis, K.F., (1979), Applied Econometrics
3. Dhrymes, P.J, (1974), Econometrics, Springer-Verlg, N.Y.
4. Goldberger, A.S., (1964), Econometric Theory, Wiley & Sons, N.Y.
5. Johnston, J., (1984) Econometrics Methods, 3rd Ed., McGraw-Hill, N.Y.
6. Malinvaud, E., (1980), Statistical Methods of Econometrics, 3rd Ed., North Holland
7. Theil, H., (1971), Principles of Econometrics, North Holland
8. Christ, C.F., (1966), Econometric Models and Methods. John Wiley & Sons, N.Y.

Stat H-405: Survival Analysis **3 Credits**

Definition: Biostatistics, survival analysis, and survival data with examples.

Basic concepts of lifetime distributions: Probability density function, cumulative distribution function, survival function, hazard function, and their interrelationships; quantile lifetime and mean residual life function.

Important lifetime distributions: Exponential, Weibull, extreme value, log-normal, log-logistic; survival function, hazard function, mean residual life function, quantile under different lifetime distributions, goodness of fit: graphical approach, family of location-scale and log-location-scale distributions.

Incomplete data: Censoring, left and right censoring, type I (progressive type I, generalized type I etc.), type II censoring, progressive type II censoring, random censoring, construction of likelihood functions under different censoring schemes.

Brief review of estimation and test: Maximum likelihood estimation, Newton-Raphson iterative approach, Wald test, score test, likelihood ratio test.

Parametric methods: Estimation and tests for the parameters (small and large samples) under different censoring schemes of important lifetime distributions; confidence intervals, delta method, estimation, test, and confidence interval for survival function, hazard function; location, and log-location scale distributions.

Non-parametric methods: Empirical survival function, product limit approach for the estimation of survival function, Nelson-Aalen estimate of the survivor function, estimation of hazard functions, product-limit methods, standard errors, median survival time, tests, confidence intervals.

Comparison of survival curves: Comparison of two groups: log-rank (Mantel-Haenszel) test, other tests comparing two groups, comparison of more than two groups.

Text

Lawless, J.F., (2003) Statistical Models and Methods for Lifetime Data (2nd Edition). Wiley, New York

References

1. Collett, D., (2003), Modelling Survival Data in Medical Research (2^{nd} edition). Chapman & Hall/CRC
2. Klein, J.P. and Moeschberger, M.L., (2003), Survival Analysis, 2nd edition, Springer, New York
3. Cox, D.R. and Oakes, D., (1988), Analysis of Survival Data, Chapman and Hall, London
4. Kleinbaum, D.G., (1996), Survival Analysis, Springer, New York
5. Nelson, W., (1982), Applied Life Data Analysis, Wiley, New York
6. Lee, E.T., (1980), Statistical Method for Survival Data Analysis, Life Learning Publication, Belmont, California

Stat H-406: Stochastic Process **3 Credits**

Concept of stochastic process, different types of stochastic process, Markov process, transition matrix, higher transition probabilities, Chapman-Kolmogorov equation, classification of states, ergodic properties, random walk model, Gambler's ruin problem.

Markov chain: Discrete time Markov chains, continuous time Markov chains.

Homogeneous Markov process: Counting process, Poisson process, birth process, death process, birth and death process.

Branching process and renewal process.

Queuing process: Concepts, components of queuing process, queuing model, single server queues, multiple server queues, equilibrium theory, limiting properties of queues, related mathematical problems.

Text

Karlin, S. & Taylor, H.M., A first Course in Stochastic Processes, 2nd edition, Academic Press

References

1. Medhi., (1982), Stochastic Process, 2nd edition, Wiley Eastern Ltd.
2. Kulkarni, V.G., (1995), Modelling and Analysis of Stochastic Systems, Chapman and Hall
3. Gross, D. and Harris, C.M., (1976), Fundamentals of Queueing Theory, John Wiley
4. Bhat, B. R., (1986), Modern Probability Theory, Wiley Eastern Ltd.
5. Ross, S. M., (1995), Stochastic Process. 2nd edition, Wiley
6. Bartlett, M.S., (1955), Introduction to Stochastic Process. Cambridge University
7. Cinlar, E., (1975), Introduction to Stochastic Processes, Prentice-Hall
8. Kanan, D., (1992), An Introduction to Stochastic Processes, Springer
9. Isaacson, D.L. and Madsen, R.W., (1976), Markov Chains: Theory and Applications. John & Wiley
10. Murdoch. J., (1978), Queuing Theory: Worked Examples and Problems, Macmillan Press
11. Ross, S.M., (2004), Introduction to Probability Models, Academic Press

Stat H-407: Generalized Linear Models **3 Credits**

Introduction to GLMs: Statistical modeling in the context of GLMs, exponential dispersion family of distributions (definitions, properties, and examples), estimation: method of maximum likelihood, method of least squares.

Inference for GLMs: Likelihood estimation (iterative weighted least squares) and inference (asymptotic interval estimates), adequacy of a model, sampling distribution for log-likelihood statistic, log-likelihood ratio statistic (deviance), assessing goodness of fit, hypothesis testing; multiple regression: maxi-mum likelihood estimation, log-likelihood ratio statistic.

Models for categorical responses: Models for binary responses - logistic regression models, probit models, maximum likelihood estimation and log-likelihood ratio statistic, goodness of fit, least square methods, multinomial models for nominal or ordinal response - logistic regression models.

Models for count data: Log-linear models: probability distributions, maximum likelihood estimation, hypothesis testing and goodness of fit.

Text

Dobson A., (2008). An introduction to generalized linear models, 3rd edition. Chapman & Hall

References

1. Agresti, A., (2002), Categorical Data Analysis 2nd Edition. Wiley
2. Johnson, V.E. and Albert, J.H., (1999), Ordinal Data Modeling. Springer

3. McCullagh, P. and Nelder, J.A., (1999), Generalized Linear Models, 2nd Edition. Chapman & Hall/CRC
4. D. Dey, S.K. Ghosh, B.K. Mallick (editors), (2000), Generalized Linear Models: A Bayesian Perspective. Biostatistics (New York, N.Y.), Marcel Dekker
5. Gill, J., (2001), Generalized Linear Models: A United Approach. Series: Quantitative Applications in the Social Sciences, Sage University Papers, Thousand Oaks
6. Hardin, J.W., and Hilbe, J.M., (2012), Generalized Linear Models and Extensions (Third Edition)
7. Hastie, T.J. and Tibshirani, R.J., (1990), Generalized Additive Models. London: Chapman and Hall
8. Ho_mann, J.P., (2003), Generalized Linear Models, An Applied Approach. Pearson Allyn & Bacon
9. Jorgensen, B., (1997), The Theory of Dispersion Models. Chapman and Hall
10. Lindsey, J.K., (1997), Applying Generalized Linear Models. New York: Springer
11. Myers, R.H., Montgomery, D.C. and Vining, G.G., (2001), Generalized Linear Models: With Applications in Engineering and the Sciences. Wiley

Stat H-408: Introduction to Data Science **3 Credits**

Data science concepts, applications of data science, role of statistics in data science, data planning and strategy.

Classification: Naive Bayes classification, discriminant analysis, logistic regression, evaluating classification models, strategies for imbalanced data; machine learning, statistical machine learning, K-nearest neighbors, tree models, bagging and the random forest, boosting.

Unsupervised learning: principal component analysis, K-means clustering, hierarchical clustering, model-based clustering, scaling and categorical variables.

Deep learning: feed forward neural network, back propagation, methods for training data engineering.

Text

Dirk P. Kroese, Zdravko I. Botev, Thomas Taimre, Radislav Vaisman, (2023), Data Science and Machine Learning.

Reference

Peter Bruce, Andrew Bruce, and Peter Gedeck, (2020), Practical Statistics for Data Scientists, 2nd Edition, O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol

Stat H-409: Comprehensive **2 Credits**

Definition of modern statistics, its applications; measurement scales and variables, data classification, presentation of data; measures of location, dispersion, skewness, kurtosis and their properties; moments, correlation and regression.

Elements of probability, some basic distributions.
Basic concepts of sampling, sampling frame, sample versus census, requirements of a good sample, selection bias, measurement bias, sampling and non-sampling errors, probability and non-probability samples, types of probability samples, framework for probability sampling.

Simple random sampling, estimates of population characteristics and standard errors, confidence intervals, sampling for proportions, determination of sample size for estimating mean and proportions, design effect, χ^2, F and t distributions, their uses in statistics.

Concept of simple regression analysis and multiple regression analysis.

Basic demographic measures, life table.

Concept of statistical inference, methods of estimation, criteria of a good estimator, test of hypothesis: parametric tests, non-parametric tests.

References
See relevant texts regarding the contents.

Stat H-410: Computing VIII (Multivariate Analysis; Design and Analysis of Experiments) **2 Credits**

Multivariate Analysis

Drawing samples from univariate and multivariate distributions, multivariate normality test, inference of mean vector and variance-covariance matrix of multivariate population, comparison of several multivariate means, MANOVA, multivariate multiple regression estimation.

Design and Analysis of Experiments

ANOVA, ANCOVA, missing plots techniques, relative efficiency, split plot designs, covariance analysis, analysis of 2^n factorial experiments, confounding, different designs with more than one observation per cell, analysis of nested designs, covariance analysis, analysis of different advanced designs.

References
See the references for **Stat H-401** and **Stat H-403**.

Stat H-411: Computing IX (Time Series Modeling; Survival Analysis) **2 Credits**

Time Series Modeling

Determination of components of time data, periodogram analysis, correlogram analysis, demand analysis, fitting of production functions, forecasting by fitted functions, confidence intervals for predicted values.

Survival Analysis

Fitting of survival distributions, non-parametric estimation of survival and hazard functions, standard errors and confidence intervals, comparison of survival curves.

References

See the references for **Stat H-402** and **Stat H-405**.

Stat H-412: Computing X (Econometrics; Generalized Linear Models) 2 Credits

Econometrics

Test on model adequacy, fitting of regression models, estimation of parameters in generalized linear model assuming the presence of autocorrelation and heteroscedasticity, test on heteroscedasticity, autocorrelation, and multicollinearity.

Generalized Linear Models

Estimation of method of maximum likelihood, method of least squares of exponential family, fitting logistic regression and Poisson regression.

References

See the references for **Stat H-404** and **Stat H-407**.

Stat H-413: Research Project 2 Credits

Organization of project group: Students will be divided into groups. Students of each group will do one research project together. Each group will be supervised by a teacher.

Conducting the project: Preparing a proposal for project, such as, selecting a topic, determining sample size, use of primary/secondary/simulated data, data processing and analysis, writing the report.

Evaluation of the project: 60% marks will be allocated for research report, 20% marks will be for presentation (each student has to present a part of the report separately) and 20% marks will be based on meetings attended by individual student with the supervisor.

Stat H-414: Viva Voce 2 Credits