STATISTICS AND MATHEMATICS

Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
STAT 501	MATHEMATICAL METHODS FOR APPLIED SCIENCES	1+1
STAT 511	STATISTICAL METHODS FOR APPLIED SCIENCES	2+1
STAT 512	EXPERIMENTAL DESIGNS	2+1
STAT 513	SAMPLING TECHNIQUES	2+1
STAT 521	APPLIED REGRESSION ANALYSIS	2+1
STAT 531	DATA ANALYSIS USING STATISTICAL PACKAGES	2+1
STAT 560*	PROBABILITY THEORY	2+0
STAT 561*	STATISTICAL METHODS	2+1
STAT 562*	STATISTICAL INFERENCE	2+1
STAT 563*	MULTIVARIATE ANALYSIS	2+1
STAT 564*	DESIGN OF EXPERIMENTS	2+1
STAT 565*	SAMPLING TECHNIQUES	2+1
STAT 566*	STATISTICAL GENETICS	2+1
STAT 567*	REGRESSION ANALYSIS	1+1
STAT 568*	STATISTICAL COMPUTING	1+1
STAT 569*	TIME SERIES ANALYSIS	1+1
STAT 570	ACTUARIAL STATISTICS	1+1
STAT 571	BIOINFORMATICS	1+1
STAT 572	ECONOMETRICS	1+1
STAT 573	STATISTICAL QUALITY CONTROL	1+1
STAT 574	OPTIMIZATION TECHNIQUES	1+1
STAT 575	DEMOGRAPHY	1+1
STAT 576	STATISTICAL METHODS FOR LIFE SCIENCES	1+1
STAT 577	STATISTICAL ECOLOGY	1+1
STAT 591	MASTER'S SEMINAR	1+0
STAT 599	MASTER'S RESEARCH	20
STAT 551	MATHEMATICAL METHOD	
STAT 552	MATHEMATICAL METHODS	

* Compulsory for Master's programme

Minor Departments **9**

Computers

Agricultural Economics

Supporting Departments **5**

Statistics

Non credit compulsory courses

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATION SKILLS	0+1
PGS 503 (e-course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-course)	DISASTER MANAGEMENT	1+0

STAT 560 PROBABILITY THEORY 2(2+0)

Objective

This is a fundamental course in Statistics. This course lays the foundation of probability theory, random variable, probability distribution, mathematical expectation, etc. which forms the basis of basic statistics.

Theory

UNIT I

Basic concepts of probability- Elements of measure theory: class of sets, field, sigma field, minimal sigma field, Borel sigma field in R, measure, probability measure, Axiomatic approach to probability, properties of probability based on axiomatic definition, Addition and multiplication theorems, conditional probability and independence of events; Bayes theorem.

UNIT II

Random variables: definition of random variable, discrete and continuous, functions of random variables, Probability mass function and Probability density function, Distribution function and its properties, Notion of bivariate random variables, bivariate distribution function and its properties; Joint, marginal and conditional distributions; Independence of random variables, Transformation of random variables (two dimensional case only). Mathematical expectation: Mathematical expectation of functions of a random variable, Raw and central moments and their relation, covariance, skewness and kurtosis, Addition and multiplication theorems of expectation, Definition of Moment Generating Function, Cumulating Generating Function, Probability Generating Function and statements of their properties.

UNIT III

Conditional Expectation and Conditional Variance, Characteristic function and its properties, Inversion and Uniqueness Theorems, Functions, which cannot be characteristic functions, Chebyshev, Markov, Cauchy-Schwartz, Jenson, Liapounov, Holder's and Minkowsky's inequalities, Sequence of random variables and modes of convergence (convergence in distribution, in probability, almost surely, and quadratic mean) and their interrelations. Statement of Slutsky's theorem, Borel –Cantelli lemma and Borel 0-1 law

UNIT IV

Laws of large numbers: WLLN, Bernoulli and Kintchin's WLLN. Kolmogorov inequality, Kolmogorov's SLLNs. Central Limit theorems: Demoviere- Laplace CLT, Lindberg – Levy CLT, Liapounov CLT, Statement of Lindeberg-Feller CLT and simple applications, Definition of quantiles and statement of asymptotic distribution of sample quantiles.

UNIT V

Classification of Stochastic Processes, Examples, Markov Chain and classification of States of Markov Chain

References

Ash RB. 2000. *Probability and Measure Theory*. 2nd Ed. Academic Press

Billingsley P. 1986. *Probability and Measure*. 2nd Ed. John Wiley

Capinski M & Zastawniah. 2001. *Probability Through Problems*. Springer

Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.

Feller W. 1972. *An Introduction to Probability Theory and its Applications*. Vols. I., II. John Wiley.

Loeve M. 1978. *Probability Theory*. 4th Ed. Springer.

Marek F. 1963. *Probability Theory and Mathematical Statistics*. John Wiley.

Rohatgi VK & Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.

STAT 561 STATISTICAL METHODS 3(2+1)

Objective

This course lays the foundation of probability distributions and sampling distributions and their application which forms the basis of Statistical Inference. Together with probability theory, this course is fundamental to the discipline of Statistics.

Theory

UNIT I

Descriptive statistics: probability distributions: Discrete probability distributions ~ Bernoulli, Binomial, Poisson, Negative-binomial, Geometric and Hyper Geometric and Uniform Distributions ~ Properties of these distributions and real life examples, Continuous Probability Distributions ~ Rectangular, Exponential, Cauchy, Normal, Gamma, Beta, Weibull, Lognormal, Logistic and Pareto Distributions~ Properties of these distributions, Probability distributions of functions of random variables.

UNIT II

Concepts of compound, truncated and mixture distributions (definitions and examples), Pearsonian curves and its various types, Sampling distributions of sample mean and sample variance from Normal population, central and non–central chi-Square, *t* and *F* distributions, and their properties and inter relationships.

UNIT III

Concepts of random vectors, moments and their distributions, Bivariate Normal distribution - marginal and conditional distributions, Distribution of Quadratic forms, Cochran theorem, Correlation, Rank Correlation, correlation ratio and intra-class correlation, Regression Analysis, Partial and Multiple Correlation and Regression.

UNIT IV

Sampling distribution of Correlation Coefficient, Regression coefficient, Correlation Ratio, Intra class correlation coefficient, Categorical Data Analysis- loglinear models, Association between attributes. Variance Stabilizing Transformations

UNIT V

Order statistics, distribution of *r*-th order statistics, Joint distribution of several order statistics and their functions, Marginal Distributions of Order Statistics, distribution of Range, Median, etc

Practical

Fitting of discrete distributions and test for goodness of fit; Fitting of continuous distributions and test for goodness of fit; Fitting of truncated distribution; Computation of simple, multiple and partial correlation coefficient, correlation ratio and intra-class correlation; Regression

coefficients and regression equations; Fitting of Pearsonian curves; Analysis of association between attributes, categorical data and log-linear models.

References

Agresti A. 2002. *Categorical Data Analysis*. 2nd Ed. John Wiley.

Arnold BC, Balakrishnan N & Nagaraja HN. 1992. *A First Course inOrder Statistics*. John Wiley.

David HA & Nagaraja HN. 2003. *Order Statistics*. 3rd Ed. John Wiley.

Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.

Huber PJ. 1981. *Robust Statistics*. John Wiley.

Johnson NL, Kotz S & Balakrishnan N. 2000. *Continuous Univariate Distributions*. John Wiley.

Johnson NL, Kotz S & Balakrishnan N. 2000. *Discrete Univariate Distributions*. John Wiley.

Marek F. 1963. *Probability Theory and Mathematical Statistics*. John Wiley.

Rao CR. 1965. *Linear Statistical Inference and its Applications*. John Wiley.

Rohatgi VK & Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.

STAT 562 STATISTICAL INFERENCE 3(2+1)

Objective

This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testing of hypothesis. They would also be given the concepts of nonparametric and sequential test procedures

Theory

UNIT I

Concepts of point estimation: MSE, unbiasedness, consistency, efficiency and sufficiency, statement of Neyman's Factorization theorem with applications, MVUE, Rao-Blackwell theorem, completeness, Lehmann-Scheffe theorem, Fisher information, Cramer-Rao lower bound and its applications.

UNIT II

Moments, minimum chi-square, least square and maximum likelihood methods of estimation and statements of their properties, Interval estimation-Confidence level, Confidence Interval for the parameters of Normal, Exponential, Binomial and Poisson distributions.

UNIT III

Fundamental notions of hypothesis testing-statistical hypothesis, statistical test, critical region, types of errors, test function, randomized tests, level of significance, power function, most powerful tests: Neyman-Pearson fundamental lemma, MLR families and UMP tests for one parameter exponential families. Concepts of Consistency, Unbiasedness and Invariance of tests, Likelihood Ratio tests, statement of asymptotic properties of LR tests with applications (including homogeneity of variances). Relation between confidence interval estimation and testing of hypothesis

UNIT IV

Notions of Sequential vs. Fixed Sample Size techniques, Wald's SPRT for testing simple null hypothesis vs. simple alternative, Termination property of SPRT, SPRT for Binomial, Poisson, Normal and Exponential distributions. Concepts of loss, risk and decision functions, admissible and optimal decision functions, estimation and testing viewed as decision problems, conjugate families, and Bayes and Minimax decision functions with applications to estimation with Quadratic loss.

UNIT V

Non-parametric tests: Sign test, Wilcoxon Signed Rank test, Runs test for randomness, Kolmogorov – Smirnov test for goodness of fit, Median test and Wilcoxon-Mann-Whitney U-test. Chi-square test for goodness of fit and test for independence of attributes. Kruskal –Wallis and Friedman's tests. Spearman's rank correlation and Kendall's Tau tests for independence

Practical

Methods of estimation - Maximum Likelihood, Minimum Chi-Square and Moments; Confidence Interval Estimation; MP and UMP tests; Large Sample tests; Examples on Non-parametric tests-Sign Test, Wilcoxon Signed Rank Test, Runs test for randomness, Kolmogorov – Smirnov test for goodness of fit, Median test and Wilcoxon-Mann-Whitney U-test. Chi-square test for goodness of fit and test for independence of attributes. Kruskal –Wallis and Friedman's tests. Spearman's rank correlation and Kendall's Tau tests for independence Probability Ratio Test.

References

Casela G & Berger RL. 2001. *Statistical Inference*. Duxbury Thompson Learning.

Christensen R. 1990. *Log Linear Models*. Springer.

Conover WJ. 1980. *Practical Nonparametric Statistics*. John Wiley.

Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.

Gibbons JD. 1985. *Non Parametric Statistical Inference*. 2nd Ed. Marcel Dekker.

Kiefer JC. 1987. *Introduction to Statistical Inference*. Springer.

Lehmann EL. 1986. *Testing Statistical Hypotheses*. John Wiley.

Lehmann EL. 1986. *Theory of Point Estimation*. John Wiley.

Randles RH & Wolfe DS. 1979. *Introduction to the Theory of Nonparametric Statistics*. John Wiley.

Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Rohatgi VK & Saleh AK. Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.

Rohtagi VK. 1984. *Statistical Inference*. John Wiley

Sidney S & Castellan NJ Jr. 1988. *Non Parametric Statistical Methods for Behavioral Sciences*. McGraw Hill.

Wald A. 2004. *Sequential Analysis*. Dover Publ.

STAT 563 MULTIVARIATE ANALYSIS 3(2+1)

Objective

Most of the data sets in agricultural sciences are multivariate in nature. This course lays the foundation of Multivariate data analysis.

Theory

UNIT I

Concept of Random Vector, its expectation and Variance-Covariance matrix, Marginal and joint distributions, Conditional distributions and Independence of random vectors, Multinomial distribution, Multivariate Normal distribution, marginal and conditional distributions, Sample mean vector and its distribution. Maximum likelihood estimates of mean vector and dispersion matrix, Tests of hypothesis about mean vector.

UNIT II

Wishart distribution and its simple properties, Hotelling's T^2 and Mahalanobis D^2 statistics, Null distribution of Hotelling's T^2, Rao's U statistics and its distribution, Wilks criterion and statement of its properties, Concepts of discriminant analysis, computation of linear discriminant function, classification between *k* (e"2) multivariate normal populations based on LDF and Mahalanobis D^2

UNIT III

Principal Component Analysis, factor analysis (simple and multi factor models). Canonical Variables and Canonical Correlations, Cluster analysis, similarities and dissimilarities, Hierarchical clustering, Single and Complete linkage methods

UNIT IV

Path Analysis and computation of path coefficients, introduction to Multi Dimensional Scaling, some theoretical results, similarities, metric and non-metric scaling methods.

Practical

Fundamentals about MSEXCEL package for computing Matrix Inversion and Product of Matrices; Maximum Likelihood Estimates of Mean-Vector and Dispersion Matrix; Testing of hypothesis on Mean vectors of Multivariate Normal populations- Hotelling's T^2 test for Single and Two Samples; Cluster analysis, Discriminant function, Canonical Correlation, Principal Component Analysis, Factor analysis; Multivariate Analysis of Variance, Multi Dimensional Scaling.

References

Anderson TW. 1984. *An Introduction to Multivariate Statistical Analysis*. 2nd Ed. John Wiley.

Arnold SF. 1981. *The Theory of Linear Models and Multivariate Analysis.* John Wiley.

Giri NC. 1977. *Multivariate Statistical Inference*. Academic Press.

Johnson RA & Wichern DW. 1988. *Applied Multivariate Statistical Analysis*. Prentice Hall.

Kshirsagar AM. 1972. *Multivariate Analysis*. Marcel Dekker.

Muirhead RJ. 1982. *Aspects of Multivariate Statistical Theory*. John Wiley.

Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Rencher AC. 2002. *Methods of Multivariate Analysis*. 2nd Ed. John Wiley.

Srivastava MS & Khatri CG. 1979. *An Introduction to Multivariate Statistics*. North Holland.

STAT 564 DESIGN OF EXPERIMENTS 3(2+1)

Objective

Design of Experiments provides the statistical tools to get maximum information from least amount of resources. This course is meant to expose the students to the basic principles of design of experiments. The students would also be provided with mathematical background of various basic designs

Theory

UNIT I

Elements of linear estimation, Gauss Markoff Theorem, relationship between BLUEs and linear zero-functions, Aitken's transformation, test of hypothesis, analysis of variance, partitioning of degrees of freedom.

UNIT II

Orthogonality, contrasts, mutually orthogonal contrasts, analysis of covariance; Basic principles of design of experiments, uniformity trials, size and shape of plots and blocks

UNIT III

Basic designs - completely randomized design, randomized complete block design and Latin square design; orthogonal Latin squares, mutually orthogonal Latin squares (MOLS), Youden square designs, Graeco Latin squares.

UNIT IV

Balanced incomplete block (BIB) designs – general properties and analysis without and with recovery of intra block information, construction of BIB designs. Partially balanced incomplete block designs with two associate classes - properties, analysis and construction, Lattice designs, alpha designs, cyclic designs, augmented designs, general analysis of block designs.

UNIT V

Factorial Experiments, Confounding in Symmetrical Factorial Experiments (2^n and 3^n series), partial and total confounding, fractional factorials, asymmetrical factorials

UNIT VI

Designs for fitting response surface; Cross-over designs. Missing plot technique; Split plot and Strip plot design; Groups of experiments; Sampling in field experiments.

Practical

Determination of size and shape of plots and blocks from uniformity trials data; Analysis of data generated from completely randomized design, randomized complete block design; Latin square design, Youden square design; Analysis of data generated from a BIB design, lattice design, PBIB designs; $\mathbf{2^n, 3^n}$ factorial experiments without and with confounding; Split and strip plot designs, repeated measurement design; Missing plot techniques, Analysis of covariance; Analysis of Groups of experiments, Analysis of clinical trial experiments, Sampling in field experiments

References

Chakrabarti MC. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publ. House.

Cochran WG & Cox DR. 1957. *Experimental Designs*. 2nd Ed. John Wiley.

Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. Springer.

Dey A & Mukerjee R. 1999. *Fractional Factorial Plans*. John Wiley.

Dey A 1986. *Theory of Block Designs*. Wiley Eastern.

Hall M Jr. 1986. *Combinatorial Theory*. John Wiley.

John JA & Quenouille MH. 1977. *Experiments: Design and Analysis*. Charles & Griffin.

Kempthorne, O. 1976. Design and Analysis of Experiments. John Wiley.

Khuri AI & Cornell JA. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.

Kshirsagar AM 1983. *A Course in Linear Models*. Marcel Dekker.

Montgomery DC. 2005. *Design and Analysis of Experiments*. John Wiley.

Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*. John Wiley.

Searle SR. 1971. *Linear Models*. John Wiley.

Street AP & Street DJ. 1987. *Combinatorics of Experimental Designs*. Oxford Science Publ.

Design Resources Server. *Indian Agricultural Statistics Research Institute (ICAR), New Delhi-110012, India*

STAT 565 SAMPLING TECHNIQUES 3(2+1)

Objective

This course is meant to expose the students to the techniques of drawing representative samples from various populations and then preparing them on the mathematical formulations of estimating the population parameters based on the sample data. The students would also be exposed to the real life applications of sampling techniques and estimation of parameters.

Theory

UNIT I

Sample survey vs. complete survey, probability sampling, sample space, sampling design, sampling strategy; Inverse sampling; Determination of sample size; Confidence-interval; Simple random sampling, Estimation of population proportion, Stratified Random Sampling, Number of strata and optimum points of stratification.

UNIT II

Ratio and regression methods of estimation, Cluster sampling, Systematic sampling, Multistage sampling with equal probability, Separate and combined ratio estimator, Double sampling, Successive sampling –two occasions**.**

UNIT III

Non-sampling Errors– sources and classification, Non-response in surveys, Imputation methods, Randomized response techniques, Response errors –interpenetrating sub-sampling

UNIT IV

Sampling with varying probabilities with and without replacement, PPS sampling, Cumulative method and Lahiri's method of selection, Horvitz- Thompson estimator, Ordered and

unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran, Inclusion probability proportional to size sampling, PPS systematic sampling, Multistage sampling with unequal probabilities, Self weighting design PPS sampling.

UNIT V

Unbiased ratio and regression type estimators, Multivariate ratio and regression type of estimators, Design effect, Bernoulli and Poisson sampling.

Practical

Determination of sample size and selection of sample; Simple random sampling, Inverse sampling, Stratified random sampling, Cluster sampling, systematic sampling; Ratio and regression methods of estimation; Double sampling, multi-stage sampling, Imputation methods; Randomized response techniques; Sampling with varying probabilities.

References

Cassel CM, Sarndal CE & Wretman JH. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.

Chaudhari A & Stenger H. 2005. *Survey Sampling Theory and Methods*. 2nd Ed. Chapman & Hall.

Chaudhari A & Voss JWE. 1988. *Unified Theory and Strategies of Survey Sampling*. North Holland.

Cochran WG. 1977. *Sampling Techniques*. John Wiley. Hedayat AS & Sinha BK. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.

Kish L. 1965. *Survey Sampling*. John Wiley.

Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Society, Calcutta.

Raj D & Chandhok P. 1998. *Sample Survey Theory*. Narosa Publ.

Sarndal CE, Swensson B & Wretman J. 1992. *Models Assisted Survey Sampling*. Springer.

Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.

Thompson SK. 2000. *Sampling*. John Wiley.

STAT 566 STATISTICAL GENETICS 3(2+1)

Objective

This course is meant to prepare the students in applications of statistics in quantitative genetics and breeding. The students would be exposed to the physical basis of inheritance, detection and estimation of linkage, estimation of genetic parameters and development of selection indices.

Theory

UNIT I

Physical basis of inheritance, Analysis of Segregation, detection and estimation of linkage for qualitative characters, Amount of information about linkage, combined estimation, disturbed segregation

UNIT II

Gene and genotypic frequencies, Random mating and Hardy –Weinberg law, Application and extension of the equilibrium law, Fisher's fundamental theorem of natural selection, Disequilibrium due to linkage for two pairs of genes, sex-linked genes, Theory of path coefficients

UNIT III

Concepts of inbreeding, regular system of inbreeding, Forces affecting gene frequency - selection, mutation and migration, equilibrium between forces in large populations, Random genetic drift, Effect of finite population size.

UNIT IV

Polygenic system for quantitative characters, concepts of breeding value and dominance deviation, Genetic variance and its partitioning, Effect of inbreeding on quantitative characters, Multiple allelism in continuous variation, Sex-linked genes, Maternal effects - estimation of their contribution.

UNIT V

Correlations between relatives, Heritability, Repeatability and Genetic correlation, Response due to selection, Selection index and its applications in plants and animals improvement programmes, Correlated response to selection.

UNIT VI

Restricted selection index, Variance component approach and linear regression approach for the analysis of GE interactions, Measurement of stability and adaptability for genotypes. Concepts of general and specific combining ability, Diallel and partial diallel crosses - construction and analysis.

Practical

Test for the single factor segregation ratios, homogeneity of the families with regard to single factor segregation; Detection and estimation of linkage parameter by different procedures; Estimation of genotypic and gene frequency from a given data. Hardy-Weinberg law; Estimation of changes in gene frequency due to systematic forces, inbreeding coefficient, genetic components of variation, heritability and repeatability coefficient, genetic correlation coefficient; Examination of effect of linkage, epistasis and inbreeding on mean and variance of metric traits; Mating designs; Construction of selection index including phenotypic index, restricted selection index, Correlated response to selection.

References

Bailey NTJ. 1961. *The Mathematical Theory of Genetic Linkage*. Clarendon Press.

Balding DJ, Bishop M & Cannings C. 2001. *Hand Book of Statistical Genetics*. John Wiley.

Crow JF & Kimura M. 1970. *An Introduction of Population Genetics Theory*. Harper & Row.

Dahlberg G. 1948. *Mathematical Methods for Population Genetics*. Inter Science Publ.

East EM & Jones DF. 1919. *Inbreeding and Outbreeding*. J B Lippincott.

Ewens WJ. 1979. *Mathematics of Population Genetics*. Springer.

Falconer DS. 1985. *Introduction to Quantitative Genetics*. ELBL.

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Mather K. 1951. *The Measurement of Linkage in Heredity*. Methuen.

Narain P. 1990. *Statistical Genetics*. Wiley Eastern.

STAT 567 REGRESSION ANALYSIS 2(1+1)

Objective

This course is meant to prepare the students in linear and non-linear regression methods useful for statistical data analysis. They would also be provided a mathematical foundation behind these techniques and their applications in agricultural data.

Theory

UNIT I

Simple and Multiple linear regressions: Least squares fit, Properties and examples. Polynomial regression: Use of orthogonal polynomials.

UNIT II

Assumptions of regression; diagnostics and transformations; Examination of residuals ~ Studentised residuals, applications of residuals in detecting outliers, identification of influential observations, Lack of fit, Pure error, Testing homoscedasticity and normality of errors, Durbin-Watson test. Use of R^2 for examining goodness of fit

UNIT III

Concept of Least Median of Squares and its applications; Concept of Multicollinearity, Analysis of Multiple Regression Models, estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation.

UNIT IV

Weighted least squares method: Properties, and examples. Box-Cox Family of transformations. Use of dummy variables, Selection of variables: Forward selection, Backward Elimination. Stepwise and Stagewise Regressions

UNIT V

Introduction to Non-Linear Models, Non-Linear estimation: Least Squares for Non-Linear Models.

Practical

Multiple regression fitting with three and four independent variables; Estimation of residuals, their applications in outlier detection, distribution of residuals; Test of homoscedasticity, and normality, Box-Cox transformation; Restricted estimation of parameters in the model, hypothesis testing, Step wise regression analysis; Least median of squares norm, Orthogonal polynomial fitting.

References

Barnett V & Lewis T. 1984. *Outliers in Statistical Data*. John Wiley.

Belsley DA, Kuh E & Welsch RE. 2004. *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity*. John Wiley.

Chatterjee S, Hadi A & Price B. 1999. *Regression Analysis by Examples*. John Wiley.

Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.

McCullagh P & Nelder JA. 1999. *Generalized Linear Models*. 2nd Ed. Chapman & Hall.

Montgomery DC, Peck EA & Vining GG. 2003. *Introduction to Linear Regression Analysis*. 3rd Ed. John Wiley.

Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

STAT 568 STATISTICAL COMPUTING 2(1+1)

Objective

This course is meant for exposing the students in the concepts of computational techniques. Various statistical packages would be used for teaching the concepts of computational techniques

Theory

UNIT I

Introduction to statistical packages and computing: data types and structures, pattern recognition, classification, association rules, graphical methods. Data analysis principles and practice

UNIT II

ANOVA, Regression and Categorical data methods, Model formulation, fitting, diagnostics and validation; Matrix computations in linear models, Analysis of discrete data

UNIT III

Numerical linear algebra, numerical optimization, graphical techniques, numerical approximations, numerical integration and Monte Carlo methods

UNIT IV

Spatial statistics; spatial sampling; hierarchical modeling, Analysis of cohort studies, case-control studies and randomized clinical trials, techniques in the analysis of survival data and longitudinal studies, Approaches to handling missing data, and meta-analysis.

Practical

Data management, Graphical representation of data, Descriptive statistics; General linear models ~ fitting and analysis of residuals, outlier detection; Categorical data analysis, analysis

of discrete data, analysis of binary data; Numerical algorithms; Spatial modeling, cohort studies; Clinical trials, analysis of survival data; Handling missing data.

References

Agresti A. 2002. *Categorical Data Analysis*. 2nd Ed. John Wiley.

Everitt B.S. and Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.

Geisser S. 1993. *Predictive Inference: An Introduction*. Chapman & Hall.

Gelman A and Hill J. 2006. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge Univ. Press.

Gentle JE, Härdle W & Mori Y. 2004. *Handbook of Computational Statistics - Concepts and Methods*. Springer.

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Hastie T, Tibshirani R & Friedman R. 2001. *The Elements of Statistical Learning: Data Mining, Inference and Prediction*. Springer.

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Thisted RA. 1988. *Elements of Statistical Computing*. Chapman & Hall.

Venables WN & Ripley BD. 1999. *Modern Applied Statistics With S-Plus*. 3rd Ed. Springer.

STAT 569 TIME SERIES ANALYSIS 2(1+1)

Objective

This course is meant to teach the students the concepts involved in time series data. They would also be exposed to components of time series, stationary models and forecasting/ projecting the future scenarios based on time series data.

Theory

UNIT I

Components of a time-series, Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis

UNIT II

Linear stationary models: Autoregressive, Moving Average and Mixed Processes, Linear Non-Stationary Models: Autoregressive Integrated Moving Average Processes.

UNIT III

Forecasting: Minimum Mean Square forecasts and their properties, calculating and updating forecasts

UNIT IV

Model identification: Objectives, Techniques, and Initial estimates. Model estimation: Likelihood function, Sum of squares function, Least squares estimates, Seasonal Models, Intervention Analysis Models and Outlier Detection.

Practical

Time series analysis, autocorrelations, Correlogram and Periodogram; Linear Stationary Model, Linear Non-stationary model; Model identification and model estimation; Intervention analysis and outliers detection

References

Box GEP, Jenkins GM & Reinsel GC. 2007. *Time Series Analysis: Forecasting and Control*. 3rd Ed. Pearson Edu.

Brockwell PJ & Davis RA. 2002. *Introduction to Time Series and Forecasting*. 2nd Ed. Springer.

Chatterjee S, Hadi A & Price B.1999. *Regression* Analysis by Examples. John Wiley.

Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.

Johnston J. 1984. *Econometric Methods*. McGraw Hill.

Judge GG, Hill RC, Griffiths WE, Lutkepohl H & Lee TC. 1988. *Introduction to the Theory and Practice of Econometrics*. 2nd Ed. John Wiley.

Montgomery DC & Johnson LA. 1976. *Forecasting and Time Series Analysis*. McGraw Hill.

Shumway RH & Stoffer DS. 2006. *Time Series Analysis and its Applications: With R Examples*. 2nd Ed. Springer.

STAT 570 ACTUARIAL STATISTICS 2(1+1)

Objective

This course provides exposure to the specialized statistical techniques such as probability models, life tables, insurance and annuities along with the real data applications.

Theory

UNIT I

Insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality

UNIT II

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

UNIT III

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions, evaluation for special mortality laws, multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

UNIT IV

Distribution of aggregate claims, compound Poisson distribution and its applications

UNIT V

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

UNIT VI

Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions.

UNIT VII

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

UNIT VIII

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

UNIT IX

Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

Practical

Insurance and utility theory- Developing models for individual claims and their sums and survival function; Developing Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions; Developing Single decrement tables, central rates of multiple decrement, net single premiums; Applications Compound Poisson distribution in distribution of aggregate claims, Examples on computation of compound interest, nominal and effective rates of interest and discount, force of interest and discount, accumulation factor and continuous compounding, Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, Computation of Net premiums- Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits.

References

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STAT 571 BIOINFORMATICS 2(1+1)

Objective

Bioinformatics is a new emerging specialized field. This course is an integration of Statistics, Computer applications and Biology, developed specifically for understanding bioinformatics principles. .

Theory

UNIT I

Basic Biology: Cell, genes, gene structures, gene expression and regulation, Molecular tools, nucleotides, nucleic acids, markers, proteins and enzymes, bioenergetics, single nucleotide polymorphism, expressed sequence tag. Structural and functional genomics: Organization and structure of genomes, genome mapping, assembling of physical maps, strategies and techniques for genome sequencing and analysis.

UNIT II

Computing techniques: OS and Programming Languages – *Linux, perl*, *bioperl*, *cgi*, *MySQL*, *phpMyAdmin*; Coding for browsing biological databases on web, parsing & annotation of genomic sequences; Database designing; Computer networks – Internet, World wide web, Web browsers – EMBnet, NCBI; Databases on public domain pertaining to Nucleic acid sequences, protein sequences, SNPs, etc.; Searching sequence databases, Structural databases.

UNIT III

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Re-sampling techniques – Bootstrapping and Jack-knifing; Hidden Markov Models; Bayesian estimation and Gibbs sampling;

UNIT IV

Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis, Approaches to EST analysis; Pair-wise alignment techniques: Comparing two sequences, PAM and BLOSUM, Global alignment (The Needleman and Wunsch algorithm), Local Alignment (The Smith-Waterman algorithm), Dynamic programming, Pair wise database searching; Sequence analysis– BLAST and other related tools, Multiple alignment and database search using motif models, ClustalW, Phylogeny; Databases on SNPs; EM

algorithm and other methods to discover common motifs in biosequences; Gene prediction based on Neural Networks, Genetic algorithms, Hidden Markov models. Computational analysis of protein sequence, structure and function; Design and Analysis of microarray experiments

Practical:

Practical examples on computing techniques using Packages, Applications of Statistical techniques like MANOVA, Cluster Analysis, Multi Dimensional Scaling and Multiple Regression, Bootstrapping and Jack-knifing; DNA Sequence Analysis; Gene prediction based on Neural Networks, Genetic algorithms, Hidden Markov models. Computational analysis of protein sequence, structure and function; Design and Analysis of microarray experiments

References

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STAT 572 ECONOMETRICS 2(1+1)

Objective

This course is meant for training the students in econometric methods and their applications in agriculture. This course would enable the students in understanding the economic phenomena through statistical tools and economics principles

Theory

UNIT I

Representation of Economic phenomenon, relationship among economic variables, linear and non linear economic models, single equation general linear regression model, basic assumptions, Ordinary least squares method of estimation for simple and multiple regression models; summary statistics correlation matrix, co-efficient of multiple determination, standard errors of estimated parameters, tests of significance and confidence interval estimation, BLUE, properties of Least Squares estimates. Chow test, test of improvement of fit through additional regressors. Maximum Likelihood Estimation

UNIT II

Heteroscedasticity, Auto-correlation, Durbin Watson test, Multicollinearity. Stochastic regressors, Errors in variables, Use of instrumental variables in regression analysis, Dummy Variables, Distributed Lag models: Koyck's Geometric Lag scheme, Adaptive Expectation and Partial Adjustment Mode, Rational Expectation Models and test for rationality.

UNIT III

Simultaneous Equation Model: Basic rationale, Consequences of simultaneous relations, Identification problem, Conditions of Identification, Indirect Least Squares, Two-stage least squares, K-class estimators, Limited Information and Full Information Maximum Likelihood Methods, Three stage least squares, Generalized least squares, Recursive models, SURE Models, Mixed Estimation Methods, use of instrumental variables, pooling of cross-section and time series data, Principal Component Methods.

UNIT IV

Problem and Construction of index numbers and their tests; fixed and chain based index numbers; Construction of cost of living index number.

UNIT V

Demand analysis – Demand and Supply Curves; Determination of demand curves from market data. Engel's Law and the Engel's Curves, Income distribution and method of its estimation, Pareto's Curve, Income inequality measures.

Practical

Fitting of Single equation general linear regression model and testing of parameters; Fitting of Multiple Regression Models with two Independent variables, Computation of Correlation Matrix, Overall testing of regression with ANOVA and testing of parameters; Auto-correlation, Durbin Watson test, Testing the Multicollinearity in Multiple Regression; Dummy Variables, Distributed Lag models; Simultaneous Equation Model- Examining the identification of the models with examples; Application of Indirect Least Squares method of estimation; Applications of Two-stage least squares; Three stage least squares; Application of Principal Components Method and Construction of index numbers and their tests; fixed and chain based index numbers; Construction of cost of living index number.

References

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Kmenta J. 1986. *Elements of Econometrics*. 2nd Ed. University of Michigan Press.

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Verbeek M. 2008. *A Guide to Modern Econometrics*. 3rd Ed. John Wiley.

STAT 573 STATISTICAL QUALITY CONTROL 2(1+1)

Objective

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agribusiness and agro-processing industries. This course would enable the students to have an idea about the statistical techniques used in quality control.

Theory

UNIT I

Introduction to Statistical Quality Control; Control Charts for Variables–Mean, Standard Deviation and Range charts; Statistical basis; rational subgroups

UNIT II

Control charts for attributes- ‘np’, ‘p’ and ‘c’ charts.

UNIT III

Fundamental concepts of acceptance sampling plans, single, double and sequential sampling plans for attributes inspection

UNIT IV

Sampling inspection tables for selection of single and double sampling plans.

Practical

Developing Control Charts for Variables: X-Bar and R Charts; Control Charts for Attributes: np, p and c charts; Acceptance Sampling Plans: developing OC Curves, AOQ and ASN Curves for a given sampling situation using Binomial and Poisson approximation approach.

References

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Dodge HF & Romig HG. 1959. *Sampling Inspection Tables*. John Wiley.

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Montgomery DC. 2005. *Introduction to Statistical Quality Control*. 5th Ed. John Wiley.

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STAT 574 OPTIMIZATION TECHNIQUES 2(1+1)

Objective

This course is developed to provide exposure to the optimization techniques such as linear programming, non-linear programming and multiple objective programming with practical applications.

Theory

UNIT I

Classical Optimization Techniques: Necessary Conditions for an Extremum, Constrained Optimization: Lagrange Multipliers, Statistical Applications, Optimization and Inequalities, Classical Inequalities, like Cauchy-Schwarz Inequality, Jensen Inequality and Markov Inequality.

UNIT II

Numerical Methods of Optimization: Numerical Evaluation of Roots of Equations, Direct Search Methods, Sequential Search Methods – Fibonacci Search Method. Random Search Method – Method of Hooke and Jeeves, Simplex Search Method, Gradient Methods, like Newton's Method, and Method of Steepest Ascent, Nonlinear Regression and Other Statistical Algorithms, like Expectation – Maximization Algorithm.

UNIT III

Linear programming Techniques – Simplex Method, Karmarkar's Algorithm, Duality and Sensitivity Analysis, Zero-sum Two-person Finite Games and Linear Programming, Integer Programming, Statistical Applications.

UNIT IV

Nonlinear Programming and its Examples, Kuhn-Tucker Conditions, Quadratic Programming, Convex Programming, Basics of Stochastic Programming, Applications, Elements of Multiple Objective Programming, Dynamic Programming, Optimal Control Theory–Pontryagin's Maximum Principle, Time-Optimal Control Problems.

Practical

Problems based on classical optimization techniques; Problems based on optimization techniques with constraints; Minimization problems using numerical methods; Linear programming (LP) problems through graphical method; LP problem by Simplex method; LP problem using Simplex method (Two-phase method); LP problem using primal and dual method; Sensitivity analysis for LP problem; LP problem using Karmarkar's method; Problems based on Quadratic programming; Problems based on Integer programming; Problems based on Dynamic programming; Problems based on Pontryagin's Maximum Principle.

References

Rao SS. 2007. *Engineering Optimization: Theory and Practice*. 3rd Ed. New Age.

Rustagi JS. 1994. *Optimization Techniques in Statistics*. Academic Press.

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STAT 575 DEMOGRAPHY 2(1+1)

Objective

This course is meant for training the students in measures of demographic indices, estimation procedures of demographic parameters. Students would also be exposed to population projection techniques and principles involved in bioassays.

Theory

UNIT I

Introduction to vital statistics, crude and standard mortality and morbidity rates, Estimation of mortality, Measures of fertility and mortality, period and cohort measures.

UNIT II

Life tables and their applications, methods of construction of abridged life tables, Increment-Decrement Life Tables

UNIT III

Stationary and stable populations, Migration and immigration, Application of stable population theory to estimate vital rates, migration and its estimation, Demographic relations in Non-stable populations, Measurement of population growth, Lotka's model(deterministic) and intrinsic rate of growth, Measures of mortality and morbidity, Period and cohort measures

UNIT IV

Principle of biological assays, parallel line and slope ratio assays, choice of doses and efficiency in assays quantal responses, probit and logit transformations, epidemiological models.

Practical

Estimation of mortality : crude and standard mortality and morbidity rates; Measures of fertility and mortality, period and cohort measures; Construction of Life tables abridged Life Tables and Increment-Decrement Life tables; Estimation of vital rates and Migration; Measurement of population growth deterministic Model; Estimation of intrinsic rate of growth, mortality and morbidity by Period Method; Measures of mortality and morbidity by cohort measures, Estimation of Parallel line and slope ratio assays, Quantal responses by Probit Transformations, Quantal responses by Logit Transformations and Epidemiological models.

References

Cox DR. 1957. Demography. Cambridge Univ. Press.

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Fleiss JL. 1981. Statistical Methods for Rates and Proportions. John Wiley.

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STAT 576 STATISTICAL METHODS FOR LIFE SCIENCES 2(1+1)

Objective

Statistical methods applicable to analysis of data in Public Health, Clinical and Biological studies are included in this course. The students will be benefited with the applications of statistical methods in this area.

Theory

UNIT I

Proportions and counts, contingency tables, logistic regression models, Poisson regression and log-linear models, models for polytomous data and generalized linear models.

UNIT II

Computing techniques, numerical methods, simulation and general implementation of bio-statistical analysis techniques with emphasis on data applications, Analysis of survival time data using parametric and nonparametric models, hypothesis testing, and methods for analyzing censored (partially observed) data with covariates. Topics include marginal estimation of a survival function, estimation of a generalized multivariate linear regression model (allowing missing covariates and/or outcomes).

UNIT III

Proportional Hazard model: Methods of estimation, estimation of survival functions, time-dependent covariates, estimation of a multiplicative intensity model (such as Cox proportional hazards model) and estimation of causal parameters assuming marginal structural models.

UNIT IV

General theory for developing locally efficient estimators of the parameters of interest in censored data models, Rank tests with censored data, Computing techniques, numerical methods, simulation and general implementation of bio-statistical analysis techniques with emphasis on data Applications

UNIT V

Newton, scoring, and EM algorithms for maximization; smoothing methods; bootstrapping; trees and neural networks; clustering; isotonic regression; Markov chain Monte Carlo methods

Practical

Fitting of Logistic Regression models, Poisson regression and log-linear models, models for polytomous data and generalized linear models; Analysis of survival time data using parametric and nonparametric models, fitting of proportional hazard model; Newton, scoring, and EM algorithms for maximization; smoothing methods; bootstrapping; trees and neural networks; clustering; isotonic regression.

References

Biswas S. 1995. *Applied Stochastic Processes. A Biostatistical and Population Oriented Approach*. Wiley Eastern Ltd.

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Cox DR & Oakes D. 1984. *Analysis of Survival Data*. Chapman & Hall.

Hosmer DW Jr. & Lemeshow S. 1999. *Applied Survival Analysis: Regression Modeling or Time to Event*. John Wiley.

Klein JP & Moeschberger ML. 2003. *Survival Analysis: Techniques for Censored and Truncated Data*. Springer.

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STAT 577 STATISTICAL ECOLOGY 2(1+1)

Objective

This course is developed to provide exposure to statistical methods applicable to collection and analysis of ecological data

Theory

UNIT I

Ecological data, Ecological sampling; spatial pattern analysis: Distribution methods, Quadrant-variance methods, Distance methods.

UNIT II

Species-abundance relations: Distribution models, Diversity indices; Species affinity: Niche-overlap indices, inter-specific association and inter-specific co-variation.

UNIT III

Community classification: Resemblance functions, Association analysis, Cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondence analysis, Nonlinear ordination.

UNIT IV

Community interpretation: Classification Interpretation and Ordination Interpretation.

Practical

Examples on Ecological sampling; spatial pattern analysis; Quadrant-variance methods; developing Diversity indices; Species affinity: Niche-overlap indices; Developing resemblance functions, association analysis, cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondence analysis, Nonlinear ordination.

References

Pielou EC. 1970. *An introduction to Mathematical Ecology*. John Wiley.

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Young LJ, Young JH & Young J. 1998. *Statistical Ecology: A Population Perspective*. Kluwer.

STAT 551 MATHEMATICAL METHODS – I 3(2+1)

Objective

The course lays the foundation for all the courses of statistics by providing exposure to the basic mathematical methods such as Calculus, Real analysis and Numerical analysis.

Theory

UNIT I

Real Analysis: Convergence and divergence of infinite series, use of comparison tests - D'Alembert's Ratio - test, Cauchy's nth root test, Raabe's test, Kummer's test, Gauss test. Absolute and Conditional Convergence, Riemann Integration, concept of Lebesgue integration, power series, Fourier, Laplace and Laplace -Steiltjes' transformation, multiple integrals.

UNIT II

Calculus: Limit and continuity, differentiation of functions, successive differentiation, partial differentiation, mean value theorems, Taylor and Maclaurin's series, Application of Derivatives, L'Hospital's rule. Integration of rational, irrational and trigonometric functions, Application of integration

UNIT III

Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient.

UNIT IV

Numerical Analysis: Simple interpolation, divided differences, Numerical differentiation and integration.

Practical

Examples on Convergence and divergence of infinite series; D'Alembert's Ratio test and Cauchy's nth root test; Raabe's test, Kummer's test and Gauss test; Examples on Power series, Fourier, Laplace and Laplace -Steiltjes' transformation; Examples on Successive differentiation and Partial differentiation, Mean value theorems; Application of Derivatives, L'Hospital's rule; Integration of rational, irrational and trigonometric functions; Examples on Applications of integration, Differential equations of first order, Linear differential equations of higher order with constant coefficient, Examples on Simple interpolation; Examples on Numerical differentiation and integration

References

Bartle RG. 1976. *Elements of Real Analysis*. John Wiley

Chatterjee SK. 1970. *Mathematical Analysis,* Oxford & IBH

Gibson GA. 1954. *Advanced Calculus,* Macmillan

Henrice P. 1964. *Elements of Numerical Analysis*, John Wiley

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Priestley HA. 1985. *Complex Analysis*. Clarenton Press.

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Scarborough JB. 1976. *Numerical Mathematical Analysis*. Oxford & IBH.

Stewart J. 2007. *Calculus.* Thompson.

Thomas GB Jr. & Finney RL. 1996. Calculus. 9th Ed. Pearson Edu.

STAT 552 MATHEMATICAL METHODS – II 2(1+1)

Objective

This is another supporting course which is developed to understand the advanced mathematical methods that are applied in various courses of statistics. It provides exposure to advances in Linear Algebra and Matrix theory.

Theory

UNIT I

Linear Algebra: Group, ring, field and vector spaces, Sub-spaces, basis, Gram Schmidt's orthogonalization, Galois field - Fermat's theorem and primitive elements, linear transformations. Graph theory: Concepts and applications

UNIT II

Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form, Determinants, rank and inverse of matrices, Special matrices – idempotent, symmetric, orthogonal. Eigen Values and Eigen Vectors, Spectral decomposition of matrices

UNIT III

Unitary, Similar, Hadamard, Circulant, Helmert's matrices. Kronecker and Hadamard product of matrices, Kronecker Sum of Matrices, Sub-Matrices and partitioned matrices, Permutation matrices, full rank factorization, Grammian root of a symmetric matrix, Solutions of linear equations, Equations having many solutions.

UNIT IV

Generalized Inverses: Moore-Penrose inverse, Applications of g-inverse, Spectral Decomposition of Matrices, Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of matrices, Quadratic forms

Practical

Examples on Gram Schmidt's orthogonalization, Graph theory; Echelon form, Determinants, rank and inverse of matrices; Special matrices – idempotent, symmetric and orthogonal; Eigen Values and Eigen Vectors, Spectral decomposition of matrices; Unitary, Similar, Hadamard, Circulant, Helmert's matrices. Kronecker and Hadamard product of matrices, Kronecker Sum of Matrices, Sub-Matrices and partitioned matrices, Permutation matrices, full rank factorization, Grammian root of a symmetric matrix, Solutions of linear equations, Equations having many solutions; Computation of Moore-Penrose inverse, g-inverse; Differentiation and integration of matrices, Quadratic forms.

References

Aschbacher M. 2000. *Finite Group Theory*. Cambridge University Press.

Deo N. 1984. *Graph Theory with Application to Engineering and Computer Science*. Prentice Hall of India.

Gentle JE. 2007. *Matrix Algebra: Theory, Computations and Applications in Statistics*. Springer.

Graybill FE.1961. *Introduction to Matrices with Applications in Statistics*. Wadsworth Publ.

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Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.

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Robinson DJS. 1991. *A Course in Linear Algebra with Applications*. World Scientific.

Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.

Seber GAF. 2008. *A Matrix Handbook for Statisticians*. John Wiley.

STAT 501 MATHEMATICAL METHODS FOR APPLIED SCIENCES* 2(1+1)

(This Course is also a Major Course for M.Sc.(Ag) Programme in Statistics & Maths.)

Objective

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses.

Theory

UNIT I

Variables and functions; Limit and continuity, Specific functions, Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, function of a function, derivative of higher order, partial derivatives, application of derivatives in agricultural research; determination of points of inflexion, maxima and minima in optimization, etc.

UNIT II

Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral; Applications of integration in agricultural research with special reference to economics and genetics, engineering, etc.

UNIT III

Vectors and vector spaces, Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; Eigen values and Eigen vectors; Determinants - evaluation and properties of determinants, application of determinants and matrices in solution of equation for economic analysis.

UNIT IV

Set theory-set operations, finite and infinite sets, operations of set, function defined in terms of sets.

Practical

Problems on Product and Quotient Rule, logarithmic and exponential functions, trigonometric and inverse functions; function of a function, derivative of higher order and partial derivatives; Application of derivatives in agricultural research- determination of points of inflexion, maxima and minima in optimization, etc; Integration as a reverse process of differentiation -methods of

integration, reduction formulae and definite integral; Applications of integration-Area, Consumer and Producer Surplus; Problems on Matrices, notations and operations, laws of matrix algebra; Problems on Determinants; transpose and inverse of matrix; Eigen values and eigen vectors; solution of equation for economic analysis.

References

Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*., Springer.

Hohn FE. 1973. *Elementary Matrix Algebra*. Macmillan.

Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.

Stewart J. 2007. *Calculus*. Thompson.

Thomas GB. Jr. & Finney RL. 1996. *Calculus.* 9th Ed. Pearson Edu.

STAT 511 STATISTICAL METHODS FOR APPLIED SCIENCES 3(2+1)

Objective

This course is developed to provide exposure of statistical methods to the students who do not have sufficient background of statistics. The students would be exposed to the basic statistical methods which include probability, estimation, tests of significance and correlation and regression.

Theory

UNIT I

Classification, Tabulation and Graphical Representation of data, Box-Plot and Descriptive Statistics, Exploratory data analysis; Theory of Probability-Random Variable and Mathematical Expectation

UNIT II

Discrete and continuous probability distributions: Binomial, Poisson and Normal distributions and their applications. Concept of sampling distribution: chi-square, *t* and *F* distributions. Tests of significance based on Normal, chi-square, *t* and *F* distributions, Large Sample theory.

UNIT III

Introduction to theory of estimation and confidence intervals; Correlation and regression, Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients, Coefficient of Determination, Testing for heterogeneity.

UNIT IV

Non-parametric tests - Sign, Wilcoxon, Mann-Whitney U-test and Wald-Wolfowitz run test; Run test for the randomness of a sequence. Median test, Kruskal-Wallis test, Friedman two-way ANOVA by ranks and Kendall's coefficient of concordance.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson and Normal; Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square,

t and F; Confidence interval estimation and point estimation of parameters of Binomial, Poisson and Normal distribution; Correlation and regression analysis; Nonparametric tests.

References

Goon AM, Gupta MK & Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.

Goon AM, Gupta MK & Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.

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Hogg RV & Craig TT. 1978. *Introduction to Mathematical Statistics*. Macmillan.

Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.

Learning Statistics: http://freestatistics.altervista.org/en/learning.php-

Electronic Statistics Text Book: http://www.statsoft.com/textbook/stathome.html.

STAT 512 EXPERIMENTAL DESIGNS 3(2+1)

Objective

This course is developed to meet the requirements of students of agriculture and animal sciences ***other than*** Statistics. The students would be exposed to the techniques of planning, designing of experiments as well as analysis of experimental data.

Theory

UNIT I

Need for designing of experiments, characteristics of a good design; Basic principles of designs- randomization, replication and local control.

UNIT II

Uniformity Trials, Size and Shape of Plots and Blocks; Analysis of Variance; Completely Randomized Design, Randomized Block Design and Latin Square Design.

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical), Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV

Split Plot and Strip Plot Designs, Analysis of Covariance and Missing Plot Techniques in Randomized Block and Latin Square Designs; Transformations, Lattice Design - concepts, randomization procedure, analysis and interpretation of results. Response Curves and Surfaces, Experiments with mixtures.

UNIT V

Introduction to Bio-assays with applications- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD and LSD; Analysis of Factorial Experiments without and with

Confounding; Analysis with missing data; Split Plot and Strip Plot Designs; Transformation of data; Fitting of response Curves and Surfaces.

References

Cochran WG & Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.

Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. Springer.

Federer WT. 1985. *Experimental Designs*. MacMillan.

Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.

Nigam AK & Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.

Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.

Design Resources Server: www.iasri.res.in/design.

STAT 513 SAMPLING TECHNIQUES 3(2+1)

Objective

This course is developed to meet the requirements of students of agriculture and animal sciences ***other than*** Statistics. The students would be exposed to the elementary sampling techniques, which would help them in understanding the concepts involved in planning and designing their surveys.

Theory

UNIT I

Concept of Sampling: Sample Survey *vs.* complete enumeration, planning of sample survey, sampling from a finite population.

UNIT II

Simple Random Sampling, Sampling for proportion, determination of sample size; inverse sampling, Stratified sampling.

UNIT III

Cluster Sampling, PPS Sampling, Multi-Stage Sampling, Double Sampling, Systematic Sampling; Use of auxiliary information at estimation as well as selection stages.

UNIT IV

Ratio and Regression Estimators, Sampling and Non-Sampling Errors; Preparation of Questionnaire and Non-Sampling errors

Practical

Random Sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.; simple random sampling, determination of sample size; Exercises on inverse sampling, stratified sampling, cluster sampling and systematic sampling; Estimation using ratio and regression estimators; Estimation using multistage design, double sampling and PPS sampling.

References

Cochran WG. 1977. *Sampling Techniques*. John Wiley

Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.

Singh D, Singh P & Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.

Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.

STAT 521 APPLIED REGRESSION ANALYSIS 3(2+1)

Objective

This course is developed to meet the requirements of students of agriculture and animal sciences. The students would be exposed to the concepts of correlation and regression with special emphasis on diagnostic measures such as Autocorrelation, Multicollinearity and Heteroscedasticity.

Theory

UNIT I

Introduction to Correlation Analysis and its measures; Correlation from grouped data, Biserial correlation, Rank correlation; Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing

UNIT II

Autocorrelation; Durbin Watson Statistics; Analysis of collinear data; Detection and correction of Multicollinearity; Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

UNIT III

Examining the Multiple Regression Equation, Concept of Weighted Least Squares, Regression equation on grouped data; various methods of selecting the best regression equation.

UNIT IV

Heteroscedastic Models, Concept of Non-Linear Regression and fitting of Quadratic Curves; Economic and optimal dose, Orthogonal polynomial

Practical

Correlation Coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, Multicollinearity, Fitting of Quadratic Curves, Fitting of orthogonal polynomials.

References

Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.

Ezekiel M. 1963. *Methods of Correlation and Regression Analysis*. John Wiley.

Kleinbaum DG, Kupper LL, Muller KE & Nizam A. 1998. *Applied Regression Analysis and Multivariable Methods*. Duxbury Press.

Kutner MH, Nachtsheim CJ & Neter J. 2004. *Applied Linear Regression*

Models. 4th Ed. With Student CD. McGraw Hill.

STAT 531 DATA ANALYSIS USING STATISTICAL PACKAGES* 3(2+1)

(This Course is also a Major Course for M.Sc.(Ag) Programme in Statistics & Maths.)

Objective

This course provides exposure to the students in use of various statistical packages for analysis of data. It provides hands on experience in the analysis of research data.

Theory

UNIT I

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II

Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, *t* and *F* statistics.

UNIT III

Concept of Analysis Of Variance and Covariance of data for single factor, multi-factor, One-Way and Two-way classified experiments, multiple comparisons

UNIT IV

ANOVA Models- Estimation of Variance Components; testing Correlation and Regression including Multiple Regression

UNIT V

Discriminant function; Factor analysis; Principal component analysis, fitting of non-linear models; Time series data

Practical

Use of software packages for summarization and tabulation of data; obtaining descriptive statistics, graphical representation of data, Robust Estimation, Testing linearity and normality assumption, Cross tabulation of data including its statistics, cell display and table format and means for different sub-classifications; Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test for large samples - Chi-squares test, F test, One way Analysis Of Variance, pair-wise comparisons; Two-Way Analysis Of Variance, Factorial set up, fixed effect models, estimation of variance components; Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple Regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models - curve estimation models, examination of residuals; Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis, Principal Component Analysis-obtaining principal component, spectral composition; Analysis of time series data - fitting of ARIMA models.

References

Anderson CW & Loynes RM. 1987. *The Teaching of Practical Statistics*. John Wiley.

Atkinson AC. 1985. *Plots Transformations and Regression*. Oxford University Press.

Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmount, California.

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Weisberg S. 1985. *Applied Linear Regression*. John Wiley.

Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall.

Wetherill GB.1986. *Regression Analysis with Applications*. Chapman & Hall.

Learning Statistics: http://freestatistics.altervista.org/en/learning.php.

Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.

Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.

Course on Experimental design:

http://www.stat.sc.edu/~grego/courses/stat706/.

Design Resources Server: www.iasri.res.in/design.

Analysis of Data: Design Resources Server.

http://www.iasri.res.in/design/Analysis%20of%20data/Analysis%20of%2 Data.html.