6 Agricultural Statistics

TRIMESTER WISE DISTRIBUTION OF COURSES

I TRIMESTER

		L	P
PGS 504	BASIC STATISTICAL METHODS IN AGRICULTURE	2	1
AS 501	BASIC STATISTICAL METHODS	2	1
AS 550	MATHEMATICAL METHODS	4	0
AS 560	PROBABILITY THEORY	2	0
AS 561	STATISTICAL METHODS	2	1
AS 567	APPLIED MULTIVARIATE ANALYSIS	2	1
AS 568	ECONOMETRICS	2	1
AS 569	PLANNING OF SURVEYS / EXPERIMENTS	2	1
AS 572	STATISTICAL QUALITY CONTROL	2	0
AS 600	ADVANCED DESIGN OF EXPERIMENTS	1	1
AS 601	ADVANCED SAMPLING TECHNIQUES	1	1
AS 602	ADVANCED STATISTICAL GENETICS	1	1
AS 603	REGRESSION ANALYSIS	1	1
AS 604	LINEAR MODELS	2	0
AS 606	OPTIMIZATION TECHNIQUES	1	1
AS 691	SEMINAR	1	0

II TRIMESTER

PGS 504	BASIC STATISTICAL METHODS IN AGRICULTURE	2	1
AS 502	BASIC DESIGN OF EXPERIMENTS	2	1
AS 551	MATHEMATICAL METHODS IN STATISTICS	4	0
AS 562	ADVANCED STATISTICAL METHODS	2	1
AS 565	SAMPLING TECHNIQUES	3	1
AS 570	STATISTICAL MODELLING	2	1
AS 571/ MBB 509	BIOINFORMATICS	3	1
AS 573	DEMOGRAPHY	2	0

AS 605	ADVANCED STATISTICAL INFERENCE	1	1
AS 607	STOCHASTIC PROCESSES	3	0
AS 661	ADVANCED DESIGNS FOR SINGLE FACTOR EXPERIMENTS	2	1
AS 663	ADVANCED THEORY OF SAMPLE SURVEYS	2	1
AS 665	ADVANCED STATISTICAL METHODS FOR POPULATION GENETICS	2	1
AS 691	SEMINAR	1	0

III TRIMESTER

PGS 504	BASIC STATISTICAL METHODS IN AGRICULTURE	2	1
AS 503	BASIC SAMPLING AND NON-PARAMETRIC METHODS	2	1
AS 563	STATISTICAL INFERENCE	4	1
AS 564	DESIGN OF EXPERIMENTS	3	1
AS 566	STATISTICAL GENETICS	3	1
AS 608	ADVANCED BIOINFORMATICS	2	1
AS 662	ADVANCED DESIGNS FOR MULTIFACTOR EXPERIMENTS	2	1
AS 664	INFERENTIAL ASPECTS OF SURVEY SAMPLING AND ANALYSIS OF SURVEY DATA	2	1
AS 666	ADVANCED QUANTITATIVE GENETICS	2	1
AS 667	FORECASTING TECHNIQUES	1	1
AS 668	BAYESIAN INFERENCE IN SURVEY SAMPLING	1	1
AS 691	SEMINAR	1	0

Core Courses

M.Sc.: AS 551, AS 560, AS 561, AS 562, AS 563, AS 564, AS 565, AS 566, AS 567 and AS 569.

Ph.D.: AS 600, AS 601, AS 602, AS 603, AS 604 and AS 605.

AGRICULTURAL STATISTICS

Major Field : Agricultural Statistics

Minor Field : In addition to the major field, every student shall take not less than two minor fields of study (one for M.Sc. students) from disciplines other than Agricultural Statistics with at least 9 credits of course work in each.

The total minimum credit requirements of course work for M.Sc. (Ph.D.) in Agricultural Statistics is 55(45) including minor field(s). Courses AS 551, AS 560 to AS 567 and AS 569 are core courses for M.Sc. (Agricultural Statistics). AS 600 to AS 605 are core courses for Ph.D (Agricultural Statistics).

DESCRIPTION OF COURSES

PGS 504 BASIC STATISTICAL METHODS IN AGRICULTURE (2L+1P) I, II, III

Objective

This basic course is meant for students who do not have sufficient background of statistical methods. The students would be exposed to concepts of statistical methods that would help them in understanding the importance and need of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, correlation and regression, tests of significance and multivariate analytical techniques. The students would also be exposed to basic design of experiments and sample surveys.

Theory

UNIT I

Classification, tabulation and graphical representation of data. Levels of measurement. Descriptive statistics. Theory of probability. Random variable and mathematical expectation. Probability distributions: Binomial, Poisson, Normal distributions and their applications. Concept of sampling distribution: t, χ^2 and F distributions. Tests of significance based on normal, t, χ^2 and F distributions. Non-parametric tests.

UNIT II

Correlation and regression: Correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, simple and multiple linear regression model. Estimation of parameters. Coefficient of determination. Introduction to multivariate analytical tools: Principal component analysis and cluster analysis.

UNIT III

Planning of an experiment and basic principles of design of experiments. Analysis of variance. Completely randomized design (CRD), Randomized complete block design (RCBD), Latin square design (LSD). Randomization procedure, analysis and interpretation of results. Concept of factorial experiments.

UNIT IV

Planning of sample surveys. Sampling *vs* complete enumeration, Simple random sampling, Stratified sampling.

Practical

Descriptive statistics. Exercises on probability distributions. Correlation and regression analysis. Large sample tests, testing of hypothesis based on χ^2, t and F. Exercises on non-parametric tests. Principal component analysis and cluster analysis. Analysis of data obtained from CRD, RBD, LSD. Analysis of data of factorial experiments. Selection of a random sample, estimation using simple random sampling. Exercises on stratified sampling.

Suggested Readings

Campbell, R.A. 1974. *Statistics for Biologists.* Cambridge University Press.

Cochran, W.G. and Cox, G.M. 1957. *Experimental Designs.* John Wiley.

Cochran, W.G. 1959. *Sampling Techniques*. John Wiley.

Das, M. N. and Giri, N.C. 1986. *Design and Analysis of Experiments.* New Age International.

Dillon, W.R. and Goldstein, M. 1984. *Multivariate Analysis: Methods and Applications.* John Wiley.

Goon, A.M., Gupta, M.K. and Dasgupta, B. 1977. *An Outline of Statistical Theory.* Vol. I. The World Press Pvt. Ltd.

Goon, A.M., Gupta, M.K. and Dasgupta, B. 1983. *Fundamentals of Statistics.* Vol. I. The World Press Pvt. Ltd.,

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research.* John Wiley.

Gupta, S.C. and Kapoor, V.K. 2007. *Fundamentals of Mathematical Statistics.* Sultan Chand and Sons.

Panse, V.G. and Sukhatme, P.V. 1967. *Statistical Methods for Agricultural Workers.* ICAR Publication.

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

Snedecor, G.W. and Cochran, W.G. 1936. *Statistical Methods.* Oxford University.

Steel, R.G.D. and Torrie, J.H. 1960. *Principles and Procedures of Statistics.* McGraw Hill.

Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. 1984. *Sampling Theory of Surveys with Applications.* Indian Society of Agricultural Statistics.

AS 501 BASIC STATISTICAL METHODS (2L+1P) I

Objective

This course is meant for students who do not have sufficient background of statistical methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance and need of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

UNIT I

Classification, tabulation and graphical representation of data. Descriptive statistics. Theory of probability. Random variable and mathematical expectation. Box-plot, Stem & leaf plot.

UNIT II

Probability distributions: Binomial, Poisson, Negative binomial, Normal distributions and their applications. Concept of sampling distribution: t, χ^2 and F distributions. Tests of significance based on normal, t, χ^2 and F distributions.

UNIT III

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. Coefficient of determination. Polynomial regression models and their fitting. Selection of variables. Validation of models. Probit regression analysis by least squares and maximum likelihood methods. Confidence interval for sensitivity. Testing for heterogeneity.

UNIT IV

Introduction to multivariate analytical tools: dimension reduction techniques (Principal Component Analysis), cluster and discriminant function analysis.

Practicals

Descriptive statistics, Box- plots, Stem & leaf plot. Fitting of distributions: Binomial, Poisson, Negative Binomial, Normal. Large sample tests, testing of hypothesis based on exact sampling distributions: χ^2, t and F. Confidence interval estimation and point estimation of parameters of Binomial, Poisson and Normal distribution, Correlation and regression analysis, fitting of orthogonal polynomials. Applications of dimensionality reduction, cluster and discriminant function analysis.

Suggested Readings

Anderson, T.W. 1958. *An Introduction to Multivariate Statistical Analysis.* John Wiley.

Campbell, R.A. 1974. *Statistics for Biologists.* Cambridge University Press.

Dillon, W.R. and Goldstein, M. 1984. *Multivariate Analysis: Methods and Applications.* John Wiley.

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

Goon, A.M., Gupta, M.K. and Dasgupta, B. 1977. *An Outline of Statistical Theory.* Vol. I. The World Press Pvt. Ltd.

Goon, A.M., Gupta, M.K. and Dasgupta, B. 1983. *Fundamentals of Statistics.* Vol. I. The World Press Pvt. Ltd.,

Gupta, S.C. and Kapoor, V.K. 2007. *Fundamentals of Mathematical Statistics.* Sultan Chand and Sons.

Hoel, P.G. 1971. *Introduction to Mathematical Statistics.* John Wiley.

Hogg, R.V. and Craig, T.T. 1978. *Introduction to Mathematical Statistics.* Macmillan.

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

Morrison, D.F. 1976. *Multivariate Statistical Methods.* McGraw Hill.

Murray, R. 2000. *Schaum's Outline of Theory and Problems of Probability and Statistics.* McGraw Hill.

Snedecor, G.W. and Cochran, W.G. 1936. *Statistical Methods.* Oxford University.

AS 502 BASIC DESIGN OF EXPERIMENTS (2L+1P) II

Objective

This course is meant for students of agricultural sciences other than statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to the concepts of design of experiments so as to enable them to understand the concepts involved in planning, designing experiments and analysis of experimental data.

Theory

UNIT I

Basic principles of design of experiments. Uniformity trials. Analysis of variance. Completely randomized design (CRD), Randomized complete block design (RCBD), Latin square design (LSD), Balanced incomplete block (BIB) design, Resolvable block designs and their applications: Alpha design and Lattice design-concepts. Randomization procedure, analysis and interpretation of results.

UNIT II

Factorial experiments (symmetrical as well as asymmetrical). Confounding in factorial experiments - application in 2^n and 3^n factorial experiments. Factorial experiments with extra treatment(s). Split plot and Strip plot designs.

UNIT III

Groups of experiments. Analysis of covariance. Missing plot technique and its application to RCBD, LSD. Cross-over design. Sampling in field experiments. Transformation of data. Response surfaces. Experiments with mixtures.

Practicals

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments without and with confounding, Analysis of Covariance, Analysis with missing data, Split plot and strip plot designs, Groups of experiments, Transformation of data, Fitting of response surfaces.

Suggested Readings

Cochran, W.G. and Cox, G.M. 1957. *Experimental Designs.* John Wiley and Sons.

Das, M. N. and Giri, N.C. 1986. *Design and Analysis of Experiments.* New Age International.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research.* John Wiley & Sons.

Panse, V.G. and Sukhatme, P.V. 1967. *Statistical Methods for Agricultural Workers.* ICAR Publication.

Steel, R.G.D. and Torrie, J.H. 1960. *Principles and Procedures of Statistics.* McGraw Hill.

AS 503 BASIC SAMPLING AND NON-PARAMETRIC METHODS (2L+1P) III

Objective

This course is meant for students of agricultural sciences other than statistics. The students would be exposed to basic sampling techniques and non-parametric tests. It would help them in

understanding the concepts involved in planning and designing surveys, analysis of survey data, presentation of results and applying non-parametric tests. This course would be especially important to the students of social sciences.

Theory

UNIT I

Concept of sampling, sampling vs complete enumeration, planning of sample survey. Sampling from a finite population, simple random sampling, inverse sampling, stratified sampling, cluster sampling, systematic sampling, multistage sampling, double sampling. Ratio and regression method of estimation. Non-sampling errors.

UNIT II

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

Practicals

Selection of a random sample, use of random number tables, estimation using simple random sampling. Exercises on inverse sampling, stratified sampling, cluster sampling and systematic sampling. Estimation using ratio and regression estimators, Estimation using multistage design and double sampling. Exercises on various non-parametric tests.

Suggested Readings

Cochran, W.G. 1959. *Sampling Techniques*. John Wiley.

Murthy, M.N. 1958. *Sampling Theory and Methods*. Statistical Publishing Society.

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

Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. 1984. *Sampling Theory of Surveys with Applications.* Indian Society of Agricultural Statistics.

AS 550 MATHEMATICAL METHODS (4L+0P) I

Objective

This course lays the foundation of all other courses of Statistics / Agricultural Statistics discipline by preparing them to understand the importance of mathematical methods in research. The students would be exposed to the basic mathematical tools of matrix algebra, real analysis, calculus, differential equations and numerical analysis. This would prepare them to study their main courses that involve knowledge of Mathematics.

Theory

UNIT I

Calculus: Variables and functions, 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.

UNIT II

Integration of rational, irrational and trigonometric functions. Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient.

Applications of integration in agricultural research with special reference to economics, genetics, engineering etc.

UNIT III

Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form. Determinants, rank and inverse of matrices. System of linear equations. Special matrices – idempotent, symmetric, orthogonal. Eigen values and eigen vectors. 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 equations.

UNIT IV

Set theory-set operations, finite and infinite sets, operations of set, function defined in terms of sets. Numerical Analysis: Simple interpolation, Divided differences, Numerical differentiation and integration. Linear Programming: Formulation and graphical solution, simplex method, duality, transportation and assignment problem.

Suggested Readings

Ahsan, Z. 2004. *Differential Equations and Their Applications.* Prentice-hall of India Pvt. Ltd.

Bartle, R.G. 1976. *Elements of Real Analysis.* John Wiley.

Chatterjee, S.K. 1970. *Mathematical Analysis.* Oxford and IBH Publishing Co.

Coddington, E.A. 1989. *An Introduction to Ordinary Differential Equations.* Dover Publications.

Frank, A. 1962. Schaum's *Outline of Theory and Problems of Matrices.* McGraw-Hill.

Frank, A. 1967. *Theory and Problems of Differential Equations.* McGraw-Hill.

Gibson, G.A. 1954. *Advanced Calculus.* Macmillan.

Hadley, G. 2002. *Linear Programming.* Narosa Book Distributors Private Ltd.

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

Hildebrand, F.B. 1956. *Introduction to Numerical Analysis.* Tata McGraw Hill,.

Mital, K.V. 1976. *Optimisation Methods in Operations Research and Systems Analysis.* New Age International.

Narayan, S. 1953. *A Text Book of Matrices.* S. Chand and Company.

Narayan, S. 1962. *A Course of Mathematical Analysis.* S.Chand and Company,

Narayan, S. 1962. *Calculus.* S. Chand and Company,

Priestley, H.A. 1985. *Introduction to Complex Analysis.* Clarenton Press.

Rai, B., Choudhury, D.P. and Freedman, H.I. 2002. *A Course in Ordinary Differential Equations.* Narosa

Rudin, W. 1985. *Principles of Mathematical Analysis.* McGraw Hill.

Sauer, T. 2006. *Numerical Analysis with CD-Rom.* Addison Wesley.

Saxena, H.C. 2007. *Finite Differences and Numerical Analysis.* S. Chand and Company.

Scarborough, J.B. 1976. *Numerical Mathematical Analysis.* Oxford and IBH Publishing Co.

Searle, S.R. 1982. *Matrix Algebra Useful for Statistics.* John Wiley.

Stewart, J. 2007. *Calculus.* Thompson.

Taha, H.A. 1996. *Operations Research – An Introduction.* Prentice Hall.

Thomas, G.B. Jr. and Finney, R.L. 1996. *Calculus.* Pearson Education, Inc.

Walsh, G.R. 1985. *An Introduction to Linear Programming*. John Wiley.

Walter R. 1976. *Principles of Mathematical Analysis.* McGraw-Hill.

AS 551 MATHEMATICAL METHODS IN STATISTICS (4L+0P)

Objective

This is another course that supports all other courses in Statistics / Agricultural Statistics. The students would be exposed to the advances in linear algebra and matrix theory. This would prepare them to study their main courses that involve knowledge of linear algebra and matrix algebra.

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.

UNIT II

Real Analysis: Convergence and divergence of infinite series, use of comparison tests - D'Alembert's Ratio - test, Cauchy's n^{th} 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 III

Matrix Algebra: unitary, similar, hadamard, circulant, helmert's matrices. Kronecker and hadamard product of matrices. Sub-matrices and partitioned matrices, permutation matrices, full rank factorization. Equations having many solutions.

UNIT IV

Generalized inverses, Moore-Penrose inverse, applications of g-inverse. Spectral decomposition of matrices, Differentiation and integration of matrices, Quadratic forms. Graph theory: Concepts and applications. Fuzzy set theory.

Suggested Readings

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 Pvt. Ltd.

Frank, A. 1962. *Schaum's Outline of Theory and Problems of Matrices*. McGraw-Hill.

Frank, H. 1994. *Graph Theory*. Addison Wesley.

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

Graybill, F.E.1961. *Introduction to Matrices with Applications in Statistics*. Wadsworth Pub. Co.

Hadley, G. 1969. *Linear Algebra*. Addison Wesley.

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

John B. F. 2002. *A First Course in Abstract Algebra*. Addison Wesley.

Khinchin, A. I.1957. *A Course of Mathematical Analysis*. Gordon & Breach Science Pub.

Malik, S.C. and Arora, S. 1992. *Mathematical Analysis*. New Age International.

Narayan, S. 1953. *A Text Book of Matrices.* S. Chand and Company.

Rao, C.R. 1965. *Linear Statistical Inference and its Applications*. John Wiley.

Robinson, D.J.S. 1991. *A Course in Linear Algebra with Applications*. World Scientific, Singapore.

Royden, H.L. 1968. *Real Analysis*. Macmillan Library Reference.

Searle, S.R. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.

Seber, G.A.F. 2000. *A Matrix Handbook for Statisticians*. John Wiley.

Thomson, B.S., Bruckner, J.B., Bruckner A.M. 2007. *Elementary Real Analysis*. Jones and Bartlett.

Wilson, R. J. 1972. *Introduction to Graph Theory*. Academic Press.

AS 560 PROBABILITY THEORY (2L+0P) I

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. The students are also exposed to law of large numbers and central limit theorem. The students also get introduced to stochastic processes.

Theory

UNIT I

Elements of measure theory. Probability - classical and frequency definitions, axiomatic approach, laws of probability, conditional probability, Bayes theorem, Class of sets, field, sigma field, minimal sigma field, Borel sigma field in R.

UNIT II

Random variable- discrete and continuous. Probability mass and probability density functions, distribution function. Mathematical expectation and its laws. Probability generating, moment generating and characteristic functions. Inversion and Uniqueness theorems for characteristic functions. Raw and central moments and their relation.

UNIT III

Markov's, Chebychev's and Kolmogorov's inequalities. Modes of stochastic convergence. 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

Weak and strong laws of large numbers, Central limit theorems (CLT). 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.

Suggested Readings

Ash, Robert B. 2000. *Probability and Measure Theory*. Academic Press.

Bhat, B.R. 1989. *Modern Probability Theory*. Wiley Eastern Private Ltd.

Billingsley, P. 1986. *Probability and Measure*. John Wiley.

Capinski, M. and Zastawniah. 2001. *Probability Through Problems*. Springer.

Dudewicz, E.J. and Mishra, S.N. 1988. *Modern Mathematical Statistics*. John Wiley.

Emanuel Parzen. 1960. *Modern Probability Theory and its Application*. Wiley Eastern Private Ltd.

Enders, A.R.1985. *Probability Theory and Application*. International Human Resources Development Corporation.

Feller, W. 1970. *An Introduction to Probability Theory and its Applications*. John Wiley.

Janos Galambos.1984. *Introductory to Probability Theory*. Marcel Dekker.

Laha, R.G. and Rohatgi, V.K. 1979. *Probability Theory*. John Wiley.

Larson, Harold J. 1969. *Introduction to Probability Theory and Statistical Inference*, John Wiley.

Loeve, M. 1978. *Probability Theory*. Springer.

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

Pfeiffer, Paul E. 1990. *Probability for Applications*. Springer Verlog.

Robert, B.A. 2000. *Probability and Measure Theory*. Wiley Eastern Private Ltd.

Rohatgi, V.K. and Ehsan, S. 2003. *An Introduction to Probability Theory and Mathematical Statistics*. Wiley Eastern Private Ltd.

Rohatgi, V.K. and Saleh, A.K. Md. E. 2005. *An Introduction to Probability and Statistics.* John Wiley.

William Feller. 1972. *An Introduction to Probability Theory and its Applications*. Wiley Eastern Private Ltd.

AS 561 STATISTICAL METHODS (2L+1P)

Objective

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation.

Theory

UNIT I

Descriptive Statistics- exploratory data analysis techniques. Random variable.

UNIT II

Discrete probability distributions: Uniform, Bernoulli, binomial, Poisson, negative - binomial, geometric, hypergeometric, multinomial. Continuous probability distributions: rectangular, exponential, Cauchy, normal, gamma, beta, Weibull, lognormal, logistic, Pareto.

UNIT III

Exact sampling distributions. Central t, χ^2 and F distributions. Bivariate normal distribution - conditional and marginal.

UNIT IV

Correlation, rank correlation, correlation ratio, intra-class correlation. Regression analysis, partial and multiple correlation and regression.

Practicals

Exercises on Descriptive Statistics and exploratory data analysis. Fitting of discrete distributions, Fitting of continuous distributions, Computation of simple, multiple and partial correlation coefficient, correlation ratio and intra-class correlation, fitting of regression equations.

Suggested Readings

Goon, A.M., Gupta, M.K. and Dasgupta, R. 1986. *Outline of Statistics.* Vol. I. World Press.

Goon, A.M., Gupta, M.K. and Dasgupta, R. 2008. *Fundamentals of Statistics.* Vol. I. Atlantic Publishers.

Hoel, P.G. 1971. *Introduction to Mathematical Statistics*. John Wiley.

Hogg, R.V. and Craig, A.T. 1995. *Introduction to Mathematical Statistics*. Prentice-Hall.

Mood, A.M., Graybill, F.A. and Boes, D.C. 1991. *Introduction to Theory of Statistics*. Cambridge University Press.

Rohtagi, V.K. and Ehsan, M. 1991. *Introduction to Probability Theory and Mathematical Statistics*. John Wiley.

AS 562 ADVANCED STATISTICAL METHODS (2L+1P)

(Pre-requisite: AS 561)

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. The students are exposed to tests of significance, non-central distributions, order statistics. Categorical data analysis is also covered in this course.

Theory

UNIT I

Truncated and compound distributions. Fitting of orthogonal polynomials. Pearsonian curves. Categorical data analysis - loglinear models, Association between attributes. Variance stabilizing transformations.

UNIT II

Sampling distribution of correlation coefficient, regression coefficient, correlation ratio, intra class correlation coefficient.

UNIT III

Non-central t, χ^2 and F distributions. Distribution of quadratic forms. Cochran's theorem. Tests for normality. Large sample tests. Tests of significance based on t, χ^2 and F distributions.

UNIT IV

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.

Practicals

Fitting of truncated distribution, Fitting of Pearsonian curves, Analysis of association between attributes, categorical data. Fitting of non-central t, χ^2 and F distributions. Computation of Tests of significance based on t, χ^2 and F distributions. Order statistics.

Suggested Readings

Agresti, A. 2002. *Categorical Data Analysis*. John Wiley.

Arnold, B.C., Balakrishnan, N. and Nagaraja, H.N. 1992. *A First Course in Order Statistics*. John Wiley.

David, H.A. and Nagaraja, H.N. 2003. *Order Statistics*. John Wiley.

Dudewicz, E.J. and Mishra, S.N. 1988. *Modern Mathematical Statistics*. John Wiley.

Goon, A.M. Gupta, M.K. and Dasgupta, B. 1986. *Outline of Statistics.* Vol. I. World Press.

Goon, A.M., Gupta, M.K. and Dasgupta, B. 2008. *Fundamentals of Statistics,* Vol. I. Atlantic Publishers.

Hoel, P.G. 1971. *Introduction to Mathematical Statistics*. John Wiley.

Hogg, R.V. and Craig, T.T. 1995. *Introduction to Mathematical Statistics*. Prentice-Hall.

Huber, P.J. 1981. *Robust Statistics*. John Wiley.

Johnson, N.L., Kotz, S. and Balakrishnan, N. 2000. *Discrete Univariate Distributions*. John Wiley.

Johnson, N.L., Kotz, S. and Balakrishnan, N. 2000. *Continuous Univariate Distributions*. John Wiley.

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

Mood, A. M. Graybill, F.A. and Boes, D.C. 1991. *Introduction to Theory of Statistics*. Cambridge University Press.

Rao, C.R. 1965. *Linear Statistical Inference and its Applications*. John Wiley.

Rohatgi, V.K. and Ehsan, M. 1991. *Introduction to Probability Theory and Mathematical Statistics*. John Wiley.

Rohatgi, V.K. and Saleh, A.K. Md. E. 2005. *An Introduction to Probability and Statistics*. John Wiley.

Searle, S. R. 1996. *Linear Models*. Academic Press.

AS 563 STATISTICAL INFERENCE (4L+1P) III

(Pre-requisite: AS 562)

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 and elements of decision theory.

Theory

UNIT I

Point estimation, Properties of estimators: unbiasedness, consistency, efficiency and sufficiency. Frechet-Cramer-Rao inequality, Rao-Blackwell theorem, completeness and bounded completeness, Basu's theorem.

UNIT II

Methods of estimation: maximum likelihood, least squares, minimum χ^2, minimum distance, moments, maximum entropy.

UNIT III

Testing of hypothesis: randomized and non randomized tests, Neyman-Pearson lemma, power function, uniformly most powerful tests and their constructions, unbiased tests, likelihood ratio tests. Confidence-interval estimation.

UNIT IV

Sequential analysis, sequential probability ratio test. Elements of decision theory and bayesian inference.

UNIT - V

Nonparametric tests: run, sign, rank, median, Wilcoxon-Mann-Whitney, Kruskal-Wallis, Friedmann two - way ANOVA by ranks.

Practicals

Exercises on estimation of parameters using methods of maximum likelihood, minimum χ^2 and moments. Obtaining confidence interval estimates, MP and UMP tests, Large sample tests, Non-parametric tests, Sequential probability ratio test, Decision functions.

Suggested Readings

Box, G.E.P. and Tiao, G.C. 1973. *Bayesian Inference in Statistical Analysis*. Addison Wesely.

Casela, G. and Berger, R.L. 2001. *Statistical Inference*. Duxbury Thompson Learning.

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

Conover, W.J. 1980. *Practical Non-parametric Statistics*. John Wiley.

Dudewicz, E.J. and Mishra, S.N. 1988. *Modern Mathematical Statistics*. John Wiley.

Gibbons, J.D. 1985. *Non Parametric Statistical Inference*. Marcel Dekker.

Hogg, R.V. and Craig, T.T. 1978. *Introduction to Mathematical Statistics*. Macmillan.

Kendall, N.G. and Stuart, A. 1960. *Advanced Theory of Statistics.* Vol. I. Charles Griffen and Co. Ltd.

Kiefer, J.C. 1987. *Introduction to Statistical Inference*. Springer Verlag.

Lehmann E.L. 1983. *Theory of Statistical Hypotheses*. John Wiley.

Lehmann, E.L. 1986. *Theory of Point Estimation*. John Wiley.

Mood, A.M., Graybill, F.A. and Boes, D.C. 1974. *Introduction to the Theory of Statistics*. McGraw Hill.

Randles, R.H. and Wolfe, D.A. 1979. *Introduction to the Theory of Nonparametric Statistics*. John Wiley.

Rao, C.R. 1965. *Linear Statistical Inference and its Applications*. John Wiley.

Rohatgi, V.K. and Saleh, A.K. 2005. *An Introduction to Probability and Statistics*. John Wiley.

Rohatgi, V.K. and Saleh, A.K. Md. E. 2005. *An Introduction to Probability and Statistics*. John Wiley.

Rohtagi, V.K. 1984. *Statistical Inference*. John Wiley.

Siegel, S., Casellan, Jr. and Johan, N. 1988. *Nonparametric Statistical Methods for Behavioral Sciences*. McGraw Hill.

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

Wald, A. 2004. *Sequential Analysis*. Dover Publications.

AS 564 DESIGN OF EXPERIMENTS (3L+1P)

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 involving one-way and two way elimination of heterogeneity and their characterization properties. This course would also prepare the students in deriving the expressions for analysis of experimental data.

Theory

UNIT I

Basic principles of design of experiments: randomization, replication and local control. Uniformity trials: size and shape of plots and blocks. Elements of linear estimation. Analysis of variance and covariance.

UNIT II

Completely randomized design (CRD), Randomized complete block design (RCBD) and Latin square design (LSD). Mutually orthogonal latin squares. Graeco Latin squares. Missing plot techniques.

UNIT III

Factorial experiments, Confounding in symmetrical factorial experiments (2^n and 3^n series), Balanced factorial experiment. Split plot and Strip-plot designs.

UNIT IV

Balanced incomplete block (BIB) designs - general properties and analysis with and without recovery of information. Construction of BIB designs, Youden square designs, Lattice designs. Cross-over designs. Groups of experiments.

UNIT V

Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays, potency estimation.

Practicals

Uniformity trial data analysis, Analysis of data obtained from CRD, RCBD, LSD. Analysis of factorial experiments without and with confounding; Analysis with missing data, Split plot and strip plot designs. Analysis of data obtained from BIB design.

Suggested Readings

Cochran, W.G. and Cox, G.M. 1957. *Experimental Designs*. John Wiley.

Das, M.N. and Giri, N.C. 1986. *Design and Analysis of Experiments*. New Age.

Dean, A.M. and Voss, D. 1999. *Design and Analysis of Experiments*. Springer.

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

Federer, W.T. 1956. *Experimental Design –Theory and Application*. Macmillan.

Federer, W.T. 1985. *Experimental Designs*. MacMillan.

Fisher, R.A. 1953. *Design and Analysis of Experiments*. Oliver and Boyd.

Hinkelmann, K. and Kempthorne, O. 1994. *Design and Analysis of Experiments.* Vol. I. John Wiley.

Kempthorne, O. 1952. *Design and Analysis of Experiments*. John Wiley.

Nigam, A.K. and Gupta, V.K. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI.

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

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

Searle, S.R. 1996. *Linear Models*. Academic Press.

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

AS 565 SAMPLING TECHNIQUES (3L+1P) II

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

Probability sampling, simple random sampling, estimation of proportions, confidence interval, determination of sample size, inverse sampling. Sampling with varying probabilities with replacement. Stratified sampling.

UNIT II

Ratio, difference and regression estimators. Cluster sampling, multi - stage sampling with equal probability, systematic sampling, double sampling, successive sampling.

UNIT III

Non-sampling errors: sources and classification, non-response survey techniques, imputation methods, measurement errors, repeated measurement techniques, interpenetrating sub-sampling.

Practicals

Determination of sample size and selection of sample. Simple random sampling, stratified random sampling, cluster sampling, systematic sampling. Estimation using Ratio and regression methods. Double sampling, multi-stage sampling.

Suggested Readings

Cassel, C.M., Sarndal, C.E. and Wretman, J.H. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.

Chaudhari, A. and Stenger, H. 2005. *Survey Sampling Theory and Methods*. Chapman and Hall.

Chaudhari, A. and Voss, J.W.E. 1988. *Unified Theory and Strategies of Survey Sampling*. North Holland.

Cochran, W.G. 1977. *Sampling Techniques*. John Wiley.

Des Raj 1976. *Sampling Theory*. Tata-Mcgraw-Hill.

Hansen, M.H., Hurwitz, W.H. and Madow, W.G. 1993. *Sample Survey Methods and Theory*. Vol. I and Vol. II. John Wiley.

Hedayat, A.S. and Sinha, B.K. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.

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

Murthy, M.N. 1977. *Sampling Theory and Methods*. Statistical Publishing Society.

Raj, D. and Chandhok, P. 1998. *Sample Survey Theory*. Narosa Publications.

Sarndal, C.E., Swensson, B. and Wretman, J. 1992. *Models Assisted Survey Sampling*. Springer.

Singh, D. and Chaudhary, F.S. 2002. *Theory and Analysis of Sample Survey Designs*. New Age International Pvt Ltd.

Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. 1984. *Sampling Theory of Surveys with Applications*. Indian Society of Agricultural Statistics.

Thompson, S.K. 2000. *Sampling*. John Wiley.

AS 566 STATISTICAL GENETICS 3+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.

UNIT III

Forces affecting gene frequency: selection, mutation and migration, equilibrium between forces in large populations, polymorphism.

UNIT IV

Polygenic system for quantitative characters, concepts of breeding value and dominance deviation. Genetic variance and its partitioning.

UNIT V

Correlation 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. Restricted selection index, Inbreeding and cross-breeding, Changes in mean and variance.

Practicals

Test for 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. Construction of selection index including phenotypic index, restricted selection index. Correlated response to selection. Combined estimation, Disturbed segregation.

Suggested Readings

Bailey, N.T.J. 1961. *The Mathematical Theory of Genetic Linkage*. Clarendon Press, Oxford.

Balding, D.J., Bishop, M. and Cannings, C. 2001. *Handbook of Statistical Genetics*. John Wiley.

Crow, J.F. and Kimura, M. 1970. *An Introduction to Population Genetics Theory*. Harper and Row.

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

East, E.M. and Jones, D.F. 1919. *Inbreeding and Outbreeding*. J B Lippincott Co.

Ewens, W.J. 1979. *Mathematics of Population Genetics*. Springer.

Falconer, D.S. and Trudy F.C Mackay. 1985. *Introduction to Quantitative Genetics*. English Language Book, Longman, Essex.

Fisher, R.A. 1949. *The Theory of Inbreeding*. Oliver and Boyd.

Fisher, R.A. 1950. *Statistical Methods for Research Workers*. Oliver and Boyd.

Fisher, R.A. 1958. *The Genetical Theory of Natural Selection*. Dover Publication.

Jain, J.P. 1982. *Statistical Techniques in Quantitative Genetics*. Tata McGraw.

Kempthorne, O. 1957. *An Introduction to Genetic Statistics*. The Iowa State University Press.

Lerner, I.M. 1950. *Population Genetics and Animal Improvement*. Cambridge University Press.

Lerner, I.M. 1954. *Genetic Homeostasis*. Oliver and Boyd.

Lerner, I.M. 1958. *The Genetic Theory of Selection*. John Wiley.

Li, C.C. 1982. *Population Genetics*. The University of Chicago Press.

Mather, K. 1949. *Biometrical Genetics*. Methuen.

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

Mather, K. and Jinks, J.L. 1977. *Introduction to Biometrical Genetics*. Chapman and Hall.

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

AS 567 APPLIED MULTIVARIATE ANALYSIS (2L+1P) I

(Pre-requisite: AS 560, AS 561, AS 562, AS 563)

Objective

This course lays the foundation of multivariate data analysis. Most of the data sets in agricultural sciences are multivariate in nature. The exposure provided to multivariate data structure, multinomial and multivariate normal distribution, estimation and testing of parameters, various data reduction methods would help the students in having a better understanding of agricultural research data, its presentation and analysis.

Theory

UNIT I

Multivariate normal distribution, marginal and conditional distribution, Concept of random vector, its expectation and variance-covariance matrix. Marginal and joint distributions. Conditional

distributions and Independence of random vectors. Multinomial distribution. Sample mean vector and its distribution. Maximum likelihood estimates of mean vector and dispersion matrix.

UNIT II

Wishart distribution, Hotelling's T^2 and Mahalanobis' D^2 statistics, Null distribution of Hotelling's T^2. Tests of hypothesis about mean vector. Rao's U statistics and its distribution. Wilks' λ criterion and statement of its properties. Multivariate analysis of variance and covariance.

UNIT III

Concepts of discriminant analysis, computation of linear discriminant function (LDF), classification between k multivariate normal populations based on LDF and Mahalanobis D^2. Cluster analysis: k-means and Hierarchical clustering. Canonical correlations, Principal components, Factor analysis, multi-dimensional scaling and Correspondence Analysis.

Practicals

Maximum likelihood estimates of mean-vector and dispersion matrix. Testing of hypothesis on mean vectors of multivariate normal populations. Cluster analysis, Discriminant function, Canonical correlation, Principal component analysis, Factor analysis. Multivariate analysis of variance and covariance, multidimensional scaling.

Suggested Readings

Anderson, T.W. 1984. *An Introduction to Multivariate Statistical Analysis*. John Wiley.

Arnold, Steven F. 1981. *The Theory of Linear Models and Multivariate Analysis*. John Wiley.

Chatfield, C. and Collins, A.J. 1982. *Introduction to Multivariate Analysis*. Prentice Hall.

Giri, N.C. 1977. *Multivariate Statistical Inference*. Academic Press.

Johnson, R.A. and Wichern, D.W. 1988. *Applied Multivariate Statistical Analysis*. Prentice Hall.

Kshirsagar, A.M. 1972. *Multivariate Analysis*. Marcel Dekker.

Muirhead, R.J. 1982. *Aspects of Multivariate Statistical Theory*. John Wiley.

Rao, C.R. 1973. *Linear Statistical Inference and its Applications*. John Wiley.

Rencher, A.C. 2002. *Methods of Multivariate Analysis*. John Wiley.

Srivastava, M.S. and Khatri, C.G. 1979. *An Introduction to Multivariate Statistics*. North Holland.

AS 568 ECONOMETRICS (2L+1P)

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

Study of single equation linear regression models: Maximum likelihood and ordinary least-squares methods of estimation, Statistical inference in linear regression, Estimation subject to linear restrictions.

UNIT II

Use of dummy variables, Multicollinearity. Generalized least squares method of estimation, Seemingly Unrelated Regression Equations, Heteroscedasticity, Auto-correlation, Distributed lag models.

UNIT III

Elements of time-series analysis-measurement of secular trend, seasonal fluctuations, cyclical fluctuations, periodogram analysis, harmonic analysis, serial correlation and correlogram. Index numbers – their characteristics and construction. Index numbers of wholesale and consumer prices.

Practicals

Fitting of single equation linear regression models: maximum likelihood, ordinary least-squares and generalized least squares methods of estimation. Detection and handling of heteroscedasticity, auto-correlation. Fitting of distributed lag models. Exercises on studying secular trend, seasonal fluctuations, cyclical fluctuations, periodogram analysis, harmonic analysis, serial correlation and correlogram. Development of Index numbers of wholesale and consumer prices.

Suggested Readings

Alan P. 1983. *Forecasting with Univariate Box-Jenking Models*. Wiley.

Brockwell, P.J. 1996. *Introduction to Time Series Analysis and Forecasting*. Springer.

Goldberger, A.S. 1964. *Econometric Theory*. John Wiley.

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

Judge, G.C., Hill, R.C. Griffiths, W.E., Lutkepohl, H. and Lee, T.C. 1988. *Introduction to the Theory and Practice of Econometrics*. John Wiley.

Klein, L.R. 1974. *A Text Book of Econometrics*. Prentice Hall.

Kmenta, J. 1986. *Elements of Econometrics*. University of Michigan Press.

Koop, G. 2007. *Introduction to Econometrics*. John Wiley.

Koutsoyianis, A. 1997. *Theory of Econometrics*. Barner and Noble.

Maddala, G.S. 2001. *Introduction to Econometrics*. John Wiley.

Pindyck, R.S. and Rubinfeld, D.L. 1998. *Econometric Models and Economic Forecasts*. McGraw Hill.

Robert, A.Y. and Monnie M. 2000. *Introduction to Time Series Analysis and Forecasting*. Academic Press.

Theil, H. 1971. *Principles of Econometrics*. John Wiley.

Verbeek, M. 2008. *A Guide to Modern Econometrics*. John Wiley.

AS 569 PLANNING OF SURVEYS / EXPERIMENTS (2L+1P) I

(Pre-requisite: AS 502, AS 503 or AS 504, AS 565)

Objective

The students would be exposed to concepts of Agricultural statistical system in the country, various surveys conducted at national level and planning and designing of experiments.

Theory

UNIT I

Agricultural statistical system in India. Organization of agricultural and livestock census. Nature of surveys: adhoc or repetitive, methods of data collection, problem of sampling frame, choice of sampling design.

UNIT II

Agricultural surveys: some case studies, crop estimation surveys, statistics of livestock and livestock products, fisheries statistics, land use statistics. Prices of agricultural commodities. Crop forecasting. Role of different organizations engaged in data collection in India, sources of agricultural statistics.

UNIT III

Planning and designing of experiments, preparation of layout plans and field visits related to applications of designs. Sampling in field experiments. Quality of experimental data. Experiments on cultivators' fields. Long-term and rotational experiments. Intercropping and agro forestry experiments.

Practicals

Designing of schedules and instruction manuals for conducting surveys, Demonstration of conducting crop cutting experiments, livestock surveys etc. Planning and designing of experiments, Preparation of layout plans and field visits related to applications of designs. Sampling in field experiments. Analysis of data from experiments on cultivators' fields, intercropping and agro forestry experiments, long-term and rotational experiments.

Suggested Readings

Bansil, P.C. 2002. *Agricultural Statistics*. CBS Publishers.

Cochran, W.G. and Cox, G.M. 1957. *Experimental Designs.* John Wiley.

Das, M. N. and Giri, N.C. 1986. *Design and Analysis of Experiments.* New Age International.

Federer, W.T. 2002. *Statistical Design and Analysis of Intercropping Experiments.* Springer-Verlag.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research.* Wiley-interscience.

Murthy, M.N. 1977. *Sampling Theory and Methods*. Statistical Publishing Society.

Panse, V.G. and Sukhatme P.V. 1967. *Statistical Methods for Agricultural Workers.* ICAR Publication.

Raut, K.C. and Singh, D. 1976. *Methods of Collection of Agricultural Statistics in India*. IASRI.

Singh R. and Mangat N.S. 1996. *Elements of Survey Sampling*. Kluwer Academic Publishers.

Singh, D. and Chaudhary, F. S.1986. *Theory and Analysis of Sample Survey Designs.* Wiley Eastern Limited.

Steel, H.G.D. and Torrie, J.M. 1960. *Principles and Procedure of Statistics.* McGraw Hill.

Sukhatme, P.V. and Panse, V.C. 1951. *Crop Surveys in India*. Indian Society of Agricultural Statistics.

Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. 1984. *Sampling Theory of Surveys with Applications*. Indian Society of Agricultural Statistics.

AS 570 STATISTICAL MODELLING (2L+1P) II

(Pre-requisite: AS 550)

Objective

This is an advanced course in Statistical Theory that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in the area of Mechanistic nonlinear growth models.

Theory

UNIT I

Empirical and mechanistic models. Nonlinear growth models: monomolecular, logistic, Gompertz, Richards. Applications in agriculture and fisheries.

UNIT II

Formulation of nonlinear statistical model. Estimation of parameters using iterative procedures, like Taylor's , Steepest descent, Levenberg - Marquardt's. Choice of initial values. Examination of residuals and adequacy of a model. Fitting of nonlinear statistical models using nonlinear estimation procedures and software packages.

UNIT III

Applications in plant growth and animal physiology. Two-species systems. Lotka-Volterra, Leslie-Gower and Holling-Tanner non-linear prey-predator models. Volterra's principle and its applications. Gause competition model. Multi-species modelling.

UNIT IV

Compartmental modelling: first and second order input-output systems, Dynamics of a multivariable system.

Practicals

Fitting of mechanistic nonlinear models. Application of Schaefer and Fox nonlinear models, Fitting of compartmental models.

Suggested Readings

Draper, N.R. and Smith, H. 1998. *Applied Regression Analysis*. John Wiley.

France, J. and Thornley, J.H.M. 1984. *Mathematical Models in Agriculture*. Butterworths.

Godfrey, K. 1983. *Compartmental Models and their Applications*. Academic Press.

Ratkowsky, D.A. 1983. *Nonlinear Regression Modelling: A Unified Practical Approach*. Marcel Dekker.

Ratkowsky, D.A. 1990. *Handbook of Nonlinear Regression Models*. Marcel Dekker.

Seber, G.A.F. and Wild, C.J. 1989. *Nonlinear Regression*. John Wiley.

AS 571/ MBB 509 BIOINFORMATICS (3L+1P) II

Objective

To provide information on basic principles of computational biology and statistical tools used for data analysis.

Theory

UNIT I

Basic molecular biology. Introduction to the basic principles of structure/function analysis of biological molecules. Genome analysis, different types and classification of genome databases (e.g. HTGS, DNA, Protein, EST, STS, SNPs, Unigenes etc.).

UNIT II

Statistical Techniques: MANOVA, cluster analysis, discriminant analysis, principal component analysis, principal coordinate analysis, multidimensional scaling. Multiple regression analysis.

Likelihood approach in estimation and testing. Resampling techniques: Bootstrapping and Jackknifing. Markov models, hidden markov models. Bayesian estimation and Gibbs sampling.

UNIT III

DNA sequence retrieval system, various DNA and protein sequence file formats. Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments, DNA sequence analysis, different gene prediction models and gene annotation tools.

UNIT IV

Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools. Programming languages and their applications in bioinformatics.

Practicals

Different types of databases and database search and retrieval. DNA and protein sequence analysis, Similarity searching and multiple alignments, Gene annotation, Phylogenetic analysis, Sequence analysis, Protein structure prediction, Analysis of microarray data. Programming languages in bioinformatics.

Suggested Readings

Bishop, M.J. and Rawlings, C.J. 1997. *Retrieved from "http://wiki.bioinformatics.org/Likelihood%2C_Bayesian_and_MCMC_Methods_in_Genetics_%28Sorensen%29"*

DNA and Protein Sequence Analysis: A Practical Approach. Oxford University Press.

Dan, E.K. and Michael, L.R. 2002. *Fundamental Concepts of Bioinformatics*. Benjamin and Cummings.

Ewens, W.J. and Grant, G.R. 2001. *Statistical Methods in Bioinformatics: An Introduction: Statistics for Biology and Health*. Springer.

Hooman, R. and Lukas, K. B. 2005. *Bioinformatics Basics: Applications in Biological Science and Medicine.* John Wiley.

Hunt, S. and Livesy, F. 2000. *Functional Genomics: A Practical Approach*. Oxford University Press.

James, D.T. 2001. *Beginning Perl for Bioinformatics*. O'Reilly and Associates.

Jeffrey, A. 2004. *Bioinformatics in the Post-Genomic Era*: *Genome, Transcriptome, Proteome, and Information-Based Medicine*. Addison-Wesley.

Jones, N.C. and Pevzner, P.A. 2004. *An Introduction to Bioinformatics Algorithims*. MIT Press.

Koski, T. and Retrieved from *"http://wiki.bioinformatics.org/Computational_Biology_%28Wunschiers%29"*

Koskinen, T. 2001. *Hidden Markov Models for Bioinformatics*. Kluwer Academic Publishers.

Krane, D.E. and Raymer, M.L. 2002. *Fundamental Concepts of Bio-informatics*. Benjamin and Cummings.

Lesk, A.M. 2002. *Introduction to Bio-informatics*. Oxford University Press.

Michael, Y. G. and Eugene, V. K. 2003 *Frontiers in Computational Genomics.*

Percus, J.K. 2001. *Mathematics of Genome Analysis*. Cambridge University Press.

Pierre B. 2001. *Bioinformatics: The Machine Learning Approach*. Soren Brunak - MIT Press.

Sorensen, D. and Gianola, D. 2002. *Likelihood, Bayesian and MCMC Methods in Genetics*. Springer.

Stephen, A.K. and David, D.W. 2003. *Introduction to Bioinformatics: A Theoretical and Practical Approach*. Humana Press.

Timo, K. 2004. *Hidden Markov Models for Bioinformatics*. Kluwer Academic.

Tisdall, J.D. 2001. *Mastering Perl for Bioinformatics*. O'Reilly and Associates.

Tisdall, J.D. 2003. *Beginning Perl for Bioinformatics*. O'Reilly and Associates.

Wang, J.T.L., Zaki, M.J., Toivonen, H.T.T. and Shasha, D. 2004. *Data Mining in Bioinformatics*. Springer.

Wu, C.H. and McLarty, J.W. 2000. *Neural Networks and Genome Informatics*. Elsevier.

Wunschiers, R. 2004. *Computational Biology Unix/Linux, Data Processing and Programming*. Springer.

Yang, M.C.C. 2000. *Introduction to Statistical Methods in Modern Genetics*. Taylor and Francis.

AS 572 STATISTICAL QUALITY CONTROL (2L+0P)

Objective

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agri-business 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.

Suggested Readings

Cowden, D.J. 1957. *Statistical Methods in Quality Control*. Prentice Hall.

Dodge, H.F. and Romig, H.G. 1959. *Sampling Inspection Tables*. John Wiley.

Duncan, A.J. 1986. *Quality Control and Industrial Statistics*. Irwin Book Company, Illinois.

Grant, E.L. and Leavenworth, R.S. 1996. *Statistical Quality Control*. McGraw Hill.

Montgomery, D.C. 2005. *Introduction to Statistical Quality Control*. John Wiley.

Wetherill, G.B. 1977. *Sampling Inspection and Quality Control*. Halsted Press.

AS 573 DEMOGRAPHY (2L+0P)

Objectives

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 Nonstable populations. Measurement of population growth, Lotka's model (deterministic) and intrinsic rate of growth, measures of mortality and morbidity, period.

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.

Suggested Readings

Cox, D.R. 1957. *Demography*. Cambridge University Press.

Finney, D.J. 1981. *Statistical Methods in Biological Assays*. Charles Griffin.

Fleiss, J.L. 1981. *Statistical Methods for Rates and Proportions*. John Wiley.

Lawless, J.F. 1982. *Statistical Models and Methods for Lifetime Data*. John Wiley.

MacMahon, B. and Pugh, T.F. 1970. *Epidemiology- Principles and Methods*. Little Brown, Boston.

Mann, N.R., Schafer, R.E. and Singpurwalla, N.D. 1974. *Methods for Statistical Analysis of Reliability and Life Data*. John Wiley.

Newell, C. 1988. *Methods and Models in Demography*. Guilford Publications.

Preston, S., Heuveline, P. and Guillot, M. 2001. *Demography: Measuring and Modeling Population Processes*. Blackwell Publishers.

Rowland, D.T. 2004. *Demographic Methods and Concepts*. Oxford Press.

Siegel, J.S. and Swanson, D.A. 2004. *The Methods and Material of Demography*. Elsevier.

Woolson, F.R. 1987. *Statistical Methods for the Analysis of Biomedical Data*. John Wiley.

AS 600 ADVANCED DESIGN OF EXPERIMENTS (1L+1P) I

(Pre-requisite: AS 564)

Objective

This is an advanced course in Design of Experiments that aims at describing some advanced level topics for students who wish to pursue research in Design of Experiments. This course prepares students for undertaking research in this area. This also helps students for applications of this important subject to agricultural sciences.

Theory

UNIT I

Partially balanced incomplete block designs with two associate classes - properties, analysis and construction.

UNIT II

Resolvable block designs and their application: alpha designs, lattice designs. Multiple comparison procedures.

UNIT III

Fractional replication of symmetrical factorials. Asymmetrical factorials: construction and analysis of balanced confounded designs. Response surface designs, second order rotatable designs.

Practicals

Overview of MS-EXCEL, SAS, SPSS, SPBD Release 1.0, SPFE 1.0. Analysis of block designs, Analysis of Latin square type designs, group divisible designs, triangular designs, lattice designs. Analysis of fractional replications of factorial experiments, analysis of asymmetrical factorials and block designs with factorial structure. Analysis of second order response surface designs.

Suggested Readings

Cochran, W.G. and Cox, D.R. 1987. *Experimental Designs*. John Wiley.

Cox, D.R. 1958. *Planning of Experiments*. John Wiley.

Das, M.N. and Giri, N.C. 1986. *Design and Analysis of Experiments*. Wiley Eastern Ltd.

Dean, A.M. and Voss, D. 1999. *Design and Analysis of Experiments*. Springer-Verlag.

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

Dey, A. 1986. *Orthogonal Fractional Factorial Designs*. Wiley Eastern Ltd.

Dey, A. (2010). *Incomplete Block Designs*. Hindustan Book Agency (India).

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

Parsad, R., Srivastava, R. and Gupta, V.K. *Design and Analysis of Agricultural Experiments.* E-Book http://www.iasri.res.in/design.

Khuri, A.I. and Cornell, J.A. 1989. *Response Surface Designs and Analysis*. Marcel and Dekker.

Little, R.C., Freund, R.J. and Spector, P.C. 1991. *SAS System for Linear Models*. SAS Institute Inc.

Nigam, A.K. and Gupta, V.K. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI.

Nigam, A.K., Puri, P.D. and Gupta, V.K. 1988. *Characterization and Analysis of Block Designs*. Wiley Eastern Ltd.

Parsad, R., Gupta, V.K. and Khanduri, O.P. 2000. *Cataloguing and Construction of Variance Balanced Block Designs: Computer Algorithms for Construction*. IASRI.

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

Searle, S.R. 1971. *Linear Models*. John Wiley.

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

AS 601 ADVANCED SAMPLING TECHNIQUES (1L+1P) I

(Pre-requisite: AS 565)

Objective

This is an advanced course in Sampling Techniques that aims at describing some advanced level topics for students who wish to pursue research in Sampling Techniques. This course prepares

students for undertaking research in this area. This also helps them for applications of this important subject to statistical system in the country.

Theory

UNIT I

Sampling with varying probabilities without replacement, Horvitz – Thompson estimator.

UNIT II

Ordered and unordered estimators, Sampling strategies, Midzuno-Sen, Rao-Hartley-Cochran, πPS Sampling: procedures such as Brewer, Durbin and Sampford, etc.

UNIT III

Super population concept - comparison of various sampling strategies.

UNIT IV

Post – stratified estimator, imperfect frames, multiple frames, randomized response techniques.

Practicals

Sampling with varying probability, Ordered and un-ordered estimators, Sampling strategies due to Horvitz-Thompson, Midzuno-Sen, Rao-Hartley-Cochran and πPS sampling: procedures such as Brewer, Durbin and Sampford etc., Imperfect frames, Randomized response technique.

Suggested Readings

Cochran, W.G. 1959. *Sampling Techniques*. John Wiley.

Des Raj. 1968. *Sampling Theory*. McGraw-Hill.

Murthy, M.N. 1958. *Sampling Theory and Methods*. Statistical Publishing Society.

Singh, D. and Chaudhary, F.S. 1986. *Theory and Analysis of Sample Survey Designs.* Wiley Eastern Limited.

Singh, D., Singh, P. and Kumar, P. *Handbook of Sampling Methods*. IASRI.

Singh, R. and Mangat, N.S. 1996. *Elements of Survey Sampling*. Kluwer Academic Publishers.

Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. 1984. *Sampling Theory of Surveys with Applications*. Indian Society of Agricultural Statistics.

AS 602 ADVANCED STATISTICAL GENETICS (1L+1P)

(Pre-requisite: AS 566)

Objective

This is an advanced course in Statistical Genetics that aims at describing some advanced level topics for students who wish to pursue research in Statistical Genetics. This course prepares students for undertaking research in this area. This also helps them for applications of this important subject in plant and animal breeding.

Theory

UNIT I

Genetic load, random genetic drift, effect of finite population size, Theory of path coefficients. Regular systems of inbreeding.

UNIT II

Effect of inbreeding on quantitative characters. Multiple allelism in continuous variation, sex-linked genes, maternal effects - estimation of their contribution.

UNIT III

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.

Practicals

Estimation of genetic load and random genetic drift. Effect of finite population size. Estimation of path coefficients. Detection and estimation of multiple allelism in continuous variation, sex-linked genes, maternal effects. Analysis of G × E interaction, measurement of stability and adaptability. Analysis of data of diallel and partial diallel crosses.

Suggested Readings

Balding, D.J., Bishop, M. and Cannings, C. 2001. *Handbook of Statistical Genetics*. John Wiley.

Crow, J.F. and Kimura, M. 1970. *An Introduction to Population Genetics Theory*. Harper and Row.

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

East, E.M. and Jones, D.F. 1919. *Inbreeding and Outbreeding*. J B Lippincott Co., London and Philadelphia.

Ewens, W.J. 1979. *Mathematics of Population Genetics*. Springer.

Falconer, D.S. 1985. *Introduction to Quantitative Genetics*. English Language Book Society, Longman, Essex.

Fisher, R.A. 1949. *The Theory of Inbreeding*. Oliver and Boyd.

Fisher, R.A. 1958. *The Genetical Theory of Natural Selection*. Dover Publication.

Jain, J.P. and Prabhakaran, V.T. 1990. *Genetics of Populations*. South Asian Publishers Pvt. Ltd.

Jain, J.P. 1982. *Statistical Techniques in Quantitative Genetics*. Tata McGraw.

Kempthorne, O. 1957. *An Introduction to Genetic Statistics*. The Iowa State University Press.

Lerner, I.M. 1950. *Population Genetics and Animal Improvement*. Cambridge University Press.

Li, C.C. 1982. *Population Genetics*. The University of Chicago Press.

Mather, K. 1949. *Biometrical Genetics*. Methuen.

Mather, K. and Jinks, J.L. 1977. *Introduction to Biometrical Genetics*. Chapman and Hall.

Mather, K. and Jinks, J.L. 1982. *Biometrical Genetics*. Chapman and Hall.

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

Narain, P., Bhatia, V.K. and Malhotra, R. 1979. *Handbook of Statistical Genetics.* IASRI, New Delhi.

Singh, R.K. and Chaudhary, B.D. 1979. *Biometrical Methods in Quantitative Genetic Analysis*. Kalyani Publishers, New Delhi.

AS 603 REGRESSION ANALYSIS (1L+1P)

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: analysis of multiple regression models, estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation. Use of orthogonal polynomials and their fitting.

UNIT II

Regression diagnostics: overview, non-normal errors, non-constant error variances and correlated observations, nonlinearity of the model. Distribution of residuals. Test of homoscedasticity and normality. Influential observations and outliers. Multicollinearity. Transformation of data. GLS. Ridge regression, principal component regression and robust regression.

UNIT III

Model over-fitting and under-fitting, selection of variables, step-wise regression analysis. Adequacy and validation of models. Indicator variable technique. Regression with ordinal data. Non-linear regression models. Non-parametric regression.

Practicals

Fitting of simple and multiple linear regressions, polynomial regression. Sub-hypothesis testing, restricted estimation. Fitting of orthogonal polynomials. Test for non-linearity of the model, test of homoscedasticity, test for normality, tests for influential observations and outliers. Multicollinearity: detection, ridge regression and principal component regression. Robust regression. Model over-fitting and under-fitting. Selection of variables, step-wise regression analysis. Adequacy and validation of models, Indicator variable technique. Fitting regression with ordinal data. Fitting of non-linear regression models and Non-parametric regression.

Suggested Readings

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

Belsley, D.A., Kuh, E. and Welsch, R.E. 2004. *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity*. John Wiley.

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

Draper, N. R. and Smith, H. 1998. *Applied Regression Analysis*. John Wiley.

Kleinbaum, D.G. and Kupper, L.L. 1978. *Applied Regression analysis and other Multivariate Methods*. Massachusetts: Duxbury Press.

McCullagh, P. and Nelder, J.A. 1999. *Generalized Linear Models*. Chapman and Hall.

Montgomery, D.C., Peck, E. and Vining, G. 2003. *Introduction to Linear Regression Analysis*. John Wiley.

Rao, C.R. 1973. *Linear Statistical Inference and its Applications*. John Wiley.

AS 604 LINEAR MODELS **(2L+0P) I**

Objective

The students would be exposed to the theory of linear models, estimation of variance components for unbalanced data and advanced techniques for analysis of data in agriculture.

Theory

UNIT I

General Gauss Markoff set up, Gauss-Markoff's theorem, Aitken's transformation. Theory of linear estimation, test of hypothesis in linear models. Analysis of variance, partitioning of degrees of freedom. Restricted least squares. Special cases of one and two way classifications (including disproportionate cell frequencies and interaction, cross and nested classifications).

UNIT II

Analysis of covariance. Variance components models, estimation of variance components from unbalanced data. Unified theory of least-squares, MINQUE, MIVQUE. Mixed models. LAR, LASSO.

Suggested Readings

Bapat, R.B. 1993. *Linear Algebra and Linear Models*. Springer-Verlag.

Graybill, F. A. 1976. *Theory and Application of the Linear Model*. Duxbury, North Scituate.

Joshi, D.D. 1987. *Linear Estimation and Design of Experiments*. Wiley Eastern.

Rao, C. R. 2001. *Linear Inference and its Application*. Wiley Eastern.

Searle, S. R. 1998. *Variance Components*. John Wiley.

Searle, S.R. 1971. *Linear Models*. John Wiley.

Seber, G.A. F. 1996. *The Linear Hypothesis: A General Theory*. Griffin, Charles and Co. Ltd.

Sheffe, H. 1999. *Analysis of Variance*. John Wiley.

AS 605 ADVANCED STATISTICAL INFERENCE (1L+1P) II

Objective

This course aims at describing the advanced level topics in statistical methods and statistical inference. This course would prepare students to have a strong base to undertake basic and applied research in Statistics.

Theory

UNIT I

Robust estimation and robust tests. Asymptotic techniques, Bayesian inference. Estimation of density function, Conditional inference, Detection and handling of outliers in statistical data.

UNIT II

Loglinear models, saturated models, hierarchical models. Analysis of multi-dimensional contingency tables.

UNIT III

Density Estimation: density estimation in the exploration and presentation of data. Survey of existing methods. Kernel method for univariate data: Rosenblatts naïve estimator, its bias and variance. Consistency of general Kernel estimators, MSE and IMSE. Asymptotic normality of Kernel estimates of density. Estimation of distribution by method of kernels.

UNIT IV

Consistency and asymptotic normality (CAN) of real and vector parameters. Invariance of consistency under continuous transformation. Invariance of CAN estimators under differentiable transformations, generation of CAN estimators using central limit theorem. Exponential class of densities and multinomial distribution. Cramer-Huzurbazar theorem, method of scoring.

Practicals

Robust estimation and robust tests. Detection and handling of outliers in statistical data. Conditional inference, Bayesian inference, log-linear models, saturated models and hierarchal models. Estimation of density function. Analysis of multi-dimensional contingency tables.

Suggested Readings

Bishop,Y.M.M., Fienberg, S.E. and Holland, P.W. 1975. *Discrete Multivariate Analysis: Theory and Practice*. MIT Press, Cambridge.

Casela, G. and Berger, R.L. 2001. *Statistical Inference*. Duxbury Thompson Learning.

Christensen, R. 1997. *Log-Linear Models and Logistic Regression*. Springer.

Daniel, W. 1990. *Applied Nonparametric Statistics*. Houghton Mifflin, Boston.

DeGroot, M.H. 1970. *Optimal Statistical Decisions*. McGraw Hill.

Efron, B. and Tibshirani, R.J. 1993. *An Introduction to Bootstrap*. Chapman Hall/CRC.

Ferguson, T.S. 1967. *Mathematical Statistics, A Decision Theoretical Approach*. Academic Press.

Gibbons, J.D. and Chakraborty, S. 1992. *Non-Parametric Statistical Inference*. Marcel Dekker.

Gray, H.L. and Schucany, W.R. 1972. *The Generalized Jackknife Statistics*. Marcel Dekker.

Hogg, R.V. and Craig, A.T. 1999. *Introduction to Mathematical Statistics.* Prentice Hall.

Kale, B.K. 1999. *A First Course on Parametric Inference*. Narosa Publication.

Prakasa Rao, B.L.S. 1983. *Nonparametric Functional Estimation*. Academic Press.

Rao, C.R. 1965. *Linear Statistical Inference and its Applications*. John Wiley.

Silverman, B.W. 1986. *Density Estimation for Statistics and Data Analysis*. Chapman and Hall.

Silvey, S.D. 1975. *Statistical Inference*. Chapman and Hall.

Tapia, R.A. and Thompson, J.R. 1978. *Nonparametric Probability Density Estimation*. Baltimore: Johns Hopkins University Press.

Tiku, M.L., Tan, W.Y. and Balakrishnan, N. 1986. *Robust Inference*. Marcel Dekker.

Wald, A. 2004. *Sequential Analysis*. Dover Publications.

Wasserman, L. 2006. *All of Nonparametric Statistics.* Springer.

Wetherill, G.B. 1986. *Regression Analysis with Applications*. Springer.

AS 606 OPTIMIZATION TECHNIQUES (1L+1P) I

Objective

This course is meant for exposing the students to the mathematical details of the techniques for obtaining optimum solutions under constraints for desired output. They will be taught numerical methods of optimization, linear programming techniques, nonlinear programming and multiple objective programming. Students will also be exposed to practical applications of these techniques.

Theory

UNIT I

Classical and numerical methods of optimization: constrained optimization, Lagrange multipliers, necessary conditions for an extremum. Statistical applications. Optimization and inequalities. Classical inequalities, like Cauchy-Schwarz Inequality, Jensen Inequality and Markov Inequality.

UNIT II

Numerical evaluation of roots of equations. 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.

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, Kuhn-Tucker sufficient conditions. Elements of multiple objective programming, dynamic programming. Optimal control theory: Pontryagin's maximum principle, time-optimal control problems. Quadratic programming.

Practicals

Problems based on classical optimization techniques, optimization techniques with constraints, minimization problems using numerical methods. Linear programming (LP) problems through graphical method, simplex method, simplex two-phase method, primal and dual method. Sensitivity analysis for LP problem, LP problem using Karmarkar's method. Problems based on Quadratic programming, integer programming, dynamic programming. Problems based on Pontryagin's maximum principle.

Suggested Readings

Rao, S.S. 2007. *Engineering Optimization: Theory and Practice*. New Age International Publishers.

Rustagi, J.S. 1994. *Optimization Techniques in Statistics*. Academic Press.

Taha, H.A. 2007. *Operations Research: Introduction with CD*. Pearson Education.

Zeleny, M. 1974. *Linear Multiobjective Programming*. Springer.

AS 607 STOCHASTIC PROCESSES (3L+0P) II

Objective

This course aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area and helps them for applications of this important subject to agricultural sciences.

Theory

UNIT I

Basics of stochastic processes. Classification according to state space and time domain. Finite and countable state Markov chains, time-homogeneity, Chapman-Kolmogorov equations, marginal distribution and finite dimensional distributions. Classification of Markov chain. Canonical form of transition probability matrix of a Markov chain. Fundamental matrix, probabilities of absorption from transient states into recurrent classes in a finite Markov chain, mean time for absorption. Ergodic state and Ergodic chain. Stationary distribution of a Markov chain, existence and evaluation of stationary distribution. Random walk and gamblers ruin problem.

UNIT II

Birth and death processes like pure birth process, linear birth and death process, immigration-birth-death process. Discrete state continuous time Markov process: Kolmogorov difference - differential equations. Pure birth process (Yule-Fury process). Immigration-Emigration process. Linear growth process, pure death process.

UNIT III

Renewal process: renewal process when time is discrete and continuous. Renewal function and renewal density. Statements of elementary renewal theorem and Key renewal theorem.

UNIT IV

Elements of queuing processes: queues in series, queuing networks. Applications of queuing theory.

UNIT V

Epidemic processes: simple deterministic and stochastic epidemic model. General epidemic models: Kermack and McKendrick's threshold theorem. Recurrent epidemics. Chain binomial models. Diffusion processes. Diffusion limit of a random walk and Discrete branching process. Forward and backward Kolmogorov diffusion equations and their applications.

Suggested Readings

Adke, S.R. and Manjunath, S.M. 1984. *An Introduction to Finite Markov Processes*. John Wiley.

Bailey, N.T.J. 1964. *Elements of Stochastic Processes with Applications to the Natural Sciences*. Wiley Eastern Ltd.

Bartlett, M.S. 1955. *Introduction to Stochastic Processes*. Cambridge University Press.

Basawa, I.V. and Prakasa Rao, B.L.S. 1980. *Statistical Inference for Stochastic Processes*. Academic Press.

Bharucha Reid, A.T. 1960. *Elements of the Theory of Markov Processes and their Applications*. McGraw Hill.

Bhat, B.R. 2000. *Stochastic Models*: *Analysis and Applications*. New Age International India.

Cox, D.R. and Miller, H.D. 1965. *The Theory of Stochastic Processes*. Methuen.

Draper, N.R. and Smith, H. 1981. *Applied Regression Analysis*. Wiley Eastern Ltd.

France, J. and Thornley, J.H.M. 1984. *Mathematical Models in Agriculture*. Butterworths.

Karlin,S. and Taylor, H.M. 1975. *A First Course in Stochastic Processes*. Vol. 1. Academic Press.

Lawler, G.F. 1995. *Introduction to Stochastic Processes*. Chapman and Hall.

Medhi, J. 2001. *Stochastic Processes*. Wiley Eastern Ltd.

Parzen, E. 1962. *Stochastic Processes.* Holden-Day, San Francisco.

Prabhu, N.U. 1965. *Stochastic Processes*. Macmillan.

Prakasa Rao, B.L.S. and Bhat, B.R. 1996. *Stochastic Processes and Statistical Inference*. New Age International Publisher.

Ratkowsky, D.A. 1983. *Nonlinear Regression Modelling: a Unified Practical Approach*. Marcel Dekker.

Ratkowsky, D.A. 1990. *Handbook of Nonlinear Regression Models*. Marcel Dekker.

Seber, G.A.F. and Wild, C.J. 1989. *Non-linear Regression*. John Wiley.

AS 608 ADVANCED BIOINFORMATICS (2L+1P) III

(Pre-requisite: AS 571)

Objectives

This is a course on Bioinformatics that aims at exposing the students to some advanced statistical and computational techniques related to bioinformatics. This course would prepare the students in understanding bioinformatics principles and their applications.

Theory

UNIT I

Genomic databases and analysis of high-throughput data sets, Analysis of DNA sequence, Sequence annotation, ESTs, SNPs. BLAST and related sequence comparison methods. EM algorithm and other statistical methods to discover common motifs in biosequences. Multiple alignment and database search using motif models, Clustal W and others. Concepts in phylogeny. Gene prediction based on codons, decision trees. classificatory analysis, neural networks, genetic algorithms, pattern recognition, Hidden Markov models.

UNIT II

Computational analysis of protein sequence, structure and function. Modeling protein families. Expression profiling by microarray/gene chip, proteomics etc.. Multiple alignment of protein sequences. Modelling and prediction of structure of proteins. Designer proteins. Drug designing.

UNIT III

Markov Chains (MC with no absorbing states, higher order Markov dependence, patterns in sequences, Markov Chain Monte Carlo – Hastings-Metropolis algorithm, simulated annealing, MC with absorbing States). Bayesian techniques and use of Gibbs Sampling. Advanced topics in design and analysis of DNA microarray experiments.

UNIT IV

Computationally intensive methods (classical estimation methods, Bootstrap estimation and confidence intervals, hypothesis testing, multiple hypothesis testing). Evolutionary models (models of nucleotide substitution). Phylogenetic tree estimation (distances, tree reconstruction - ultrametric and neighbor-joining cases, surrogate distances, tree reconstruction, parsimony and maximum likelihood, modeling, estimation and hypothesis testing). Neural Networks (universal approximation properties, priors and likelihoods, learning algorithms - back propagation, sequence encoding and output interpretation, prediction of protein secondary structure, prediction of signal peptides and their cleavage sites, application for DNA and RNA nucleotide sequences). Analysis of SNPs and haplotypes.

Practicals

Genomic databases and analysis of high-throughput data sets, BLAST and related sequence comparison methods. Statistical methods to discover common motifs in biosequences. Multiple alignment and database search using motif models, clustalw, classificatory analysis, neural networks, genetic algorithms, pattern recognition, Hidden Markov models. Computational analysis of protein sequence. Expression profiling by microarray/gene chip, proteomics. Modelling and prediction of structure of proteins. Bayesian techniques and use of Gibbs Sampling. Analysis of DNA microarray experiments. Analysis of one DNA sequence, multiple DNA or protein sequences. Computationally intensive methods, multiple hypothesis testing, Phylogenetic tree estimation, Analysis of SNPs and haplotypes.

Suggested Readings

Retrieved from *"http://wiki.bioinformatics.org/Likelihood%2C_Bayesian_and_MCMC_Methods_in_Genetics_%28Sorensen%29"*

Baldi, P. and Brunak, S. 2001. *Bioinformatics: The Machine Learning Approach*. MIT Press.

Baxevanis, A.D. and Francis, B.F. 2004. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. John Wiley.

Duda, R.O., Hart, P.E. and Stork, D.G. 1999. *Pattern Classification*. John Wiley.

Ewens, W.J. and Grant, G.R. 2001. *Statistical Methods in Bioinformatics*. Springer.

Jones, N.C. and Pevzner, P.A. 2004. *Introduction to Bioinformatics Algorithims*. The MIT Press.

Retrieved from *"http://wiki.bioinformatics.org/Computational_Biology_%28Wunschiers%29"*

Koskinen, T. 2001. *Hidden Markov Models for Bioinformatics*. Kluwer Academic Publishers.

Krane, D.E. and Raymer, M.L. 2002. *Fundamental Concepts of Bio-informatics*. Benjamin / Cummings.

Krawetz, S.A. and Womble, D.D. 2003. *Introduction to Bioinformatics: A Theoretical and Practical Approach*. Humana Press.

Lesk, A.M. 2002. *Introduction to Bio-informatics*. Oxford University Press.

Linder, E. and Seefeld, K. 2005. *R for Bioinformatics*. O'Reilly and Associates.

Percus, J.K. 2001. *Mathematics of Genome Analysis*. Cambridge University Press.

Sorensen, D. and Gianola, D. 2002. *Likelihood, Bayesian and MCMC Methods in Genetics*. Springer.

Tisdall, J.D. 2001. *Mastering Perl for Bioinformatics*. O'Reilly and Associates.

Wang, J.T.L., Zaki, M.J., Toivonen, H.T.T. and Shasha, D. 2004. *Data Mining in Bioinformatics*. Springer.

Wu, C.H. and McLarty, J.W. 2000. *Neural Networks and Genome Informatics.* Elsevier.

Wunschiers, R. 2004. *Computational Biology Unix/Linux, Data Processing and Programming*. Springer.

Yang, M.C.C. 2000. *Introduction to Statistical Methods in Modern Genetics*. Taylor and Francis.

AS 661 ADVANCED DESIGNS FOR SINGLE FACTOR EXPERIMENTS (2L+1P) I

Objective

This is an advanced course in Design of Experiments for single factor experiments for students who wish to pursue research in Design of Experiments. This course prepares students for undertaking research in this area and also helps them for applications of this important subject to agricultural sciences.

Theory

UNIT I

General properties and analysis of block designs. Balancing criteria. m-associate partially balanced incomplete block (PBIB) designs and their association schemes including lattice designs - properties and construction. Properties and construction of mutually orthogonal latin squares.

UNIT II

Designs for two - way elimination of heterogeneity including lattice square designs. Designs for test treatment - control(s) comparisons. Nested designs, mating designs, cyclic designs, block designs with nested rows and columns.

UNIT III

Optimality criteria and optimality of designs, robustness of designs against missing observation, presence of outlying observation(s), presence of systematic trend, model inadequacy etc. Diagnostics in design of experiments.

Practicals

Analysis of data from block designs, PBIB designs, Lattice designs. Analysis of designs for two way elimination of heterogeneity, Analysis of augmented designs, Analysis of designs for test treatment - Control(s) Comparison, Analysis of mating designs. Diagnostic Study, Analysis of Lattice square designs.

Suggested Readings

Chakraborti, M.C. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publishing House.

Dean, A.M. and Voss, D. 1999. *Design and Analysis of Experiments*. Springer.

Parsad, R., Srivastava, R. and Gupta, V.K. 2004. *Design and Analysis of Agricultural Experiments.* E-Book, http://www.iasri.res.in/design.

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

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

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

John, J.A. and Quenouille, M.H. 1977. *Experiments: Design and Analysis*. Charles and Griffin Co. Ltd.

Khuri, A.I. and Cornell, J.A. 1996. *Response Surface Designs and Analysis*. Marcel Dekker.

Montgomery, D.C. 2005. *Design and Analysis of Experiments*. John Wiley.

Nigam,A.K., Puri, P.D. and Gupta,V.K. 1988. *Characterizations and Analysis of Block Designs*. Wiley Eastern.

Ogawa, J. 1974. *Statistical Theory of the Analysis of Experimental Designs*. Marcel Dekker.

Parsad R., Gupta, V.K. and Khanduri, O.P. 2000. *Cataloguing and Construction of Variance Balanced Block Designs: Computer Algorithms for Construction*. IASRI.

Parsad, R., Gupta, V.K., Batra, P.K., Satpati, S.K. and Biswas, P. 2007. *Monograph on a-designs*. IASRI.

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

Shah, K.R. and Sinha, B.K. 1989. *Theory of Optimal Designs*. Lecture notes in Statistics. Vol. 54, Springer.

Street, A.P. and Street, D.J. 1987. *Combinatorics of Experimental Designs*. Oxford Science Publication.

Shah, K.R. and Sinha, B.K.1988. *Theory of Optimality of Designs*. Marcel Decker.

AS 662 ADVANCED DESIGNS FOR MULTI FACTOR EXPERIMENTS (2L+1P) III

Objective

This is an advanced course in Design of Experiments for multi factor experiments and aims at describing some advanced level topics for students who wish to pursue research in Design of Experiments. This course prepares students for undertaking research in this area.

Theory

UNIT I

Balanced factorial experiments: characterization and analysis (symmetrical and asymmetrical factorials). Factorial experiments with extra treatment(s). Orthogonal and balanced arrays, Fractional replication, Regular and irregular fractions, minimum aberration in fractional factorials.

UNIT II

Response surface designs: symmetrical and asymmetrical factorials, response optimization and slope estimation, blocking. Canonical analysis and ridge analysis. Experiments with mixtures: Design and analysis. Experiments with qualitative cum quantitative factors. Designs for bioassays.

Practicals

Analysis of block designs with factorial treatment structure, Analysis of designs with orthogonal factorial structure, Analysis of factorial experiments with extra treatments, analysis of fractional factorial experiments. Analysis of response surface designs, Analysis of response surface with blocking, Analysis of experiments with mixtures.

Suggested Readings

Cochran, W.G. and Cox, G.M. 1957. *Experimental Designs*. John Wiley.

Cornell, J.A. 2002. *Experiments with Mixtures: Designs, Models and Analysis of Mixture Data.* John Wiley.

Dey, A. 1985. *Orthogonal Fractional Factorial Designs*. Wiley Eastern Ltd.

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

Gupta, S. and Mukerjee, R. 1989. *A Calculus for Factorial Arrangements*. Springer- Verlag.

Myers, R.H. 1971. *Response Surface Methodology*. Allyn and Bacon, Inc., Boston.

Khuri, A.I. and Cornell, J.A. 1986. *Response Surface Designs and Analysis*. Marcel Dekker.

AS 663 ADVANCED THEORY OF SAMPLE SURVEYS (2L+1P) II

Objective

This is an advanced course in the theory of sample surveys that aims at describing some advanced level topics for students who wish to pursue research in Sampling Techniques. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

UNIT I

Design effect. Number of strata and optimum stratification. Controlled selection. Two way stratification, collapsed strata.

UNIT II

Unbiased ratio and regression type estimators, multivariate ratio and regression methods of estimation. Adaptive sampling, Ranked set sampling. Systematic sampling in two dimensions.

UNIT III

Multistage sampling with unequal probabilities. Self weighting designs. Integration of surveys - Lahiri and Keyfitz's procedures.

UNIT IV

Variance estimation in complex surveys. Taylor's series linearisation, balanced repeated replication, Jackknife and bootstrap methods.

UNIT V

Use of software for survey data analysis.

Practicals

Estimation of parameters using unbiased ratio and regression type estimators, multivariate ratio and regression methods of estimation, ranked set sampling. systematic sampling in two dimensions. Applications of statistical packages for survey data analysis.

Suggested Readings

Cassel, C.M., Sarndal, C.E. and Wretman, J.H. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.

Chaudhari, A. and Stenger, H. 2005. *Survey Sampling Theory and Methods*. Chapman and Hall.

Chaudhari, A. and Voss, J.W.E. 1988. *Unified Theory and Strategies of Survey Sampling*.

Cochran, W.G. 1959. *Sampling Techniques*. John Wiley.

Hedayat, A.S. and Sinha, B.K. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.

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

Mukhopadhyay, P. 1967. *Theory and Methods of Survey sampling*. Prentice Hall.

Murthy, M.N. 1977. *Sampling Theory and Methods*. Statistical Publishing Society.

Raj, D. and Chandhok, P. 1998. *Sample Survey Theory*. Narosa Publications.

Sarndal, C.E., Swensson, B. and Wretman, J. 1992. *Model Assisted Survey Sampling*. John Wiley.

Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics.

Thompson, S.K. 2000. *Sampling*. John Wiley.

Wolter, K. 2003. *Introduction to Variance Estimation*. Springer.

AS 664 INFERENTIAL ASPECTS OF SURVEY SAMPLING AND ANALYSIS OF SURVEY DATA (2L+1P) III

Objective

This is an advanced course dealing with inferential aspect of survey sampling. It aims at describing some advanced level topics for students who wish to pursue research in inferential sampling and analysis of survey data.

Theory

UNIT I

Unified theory of sampling from finite populations. UMV - non-existence theorem and existence theorem under restricted conditions. Concept of sufficiency and likelihood in survey sampling. Admissibility and hyper-admissibility.

UNIT II

Inference under super population models - concept of designs and model unbiasedness, prediction approach. Regression analysis and categorical data analysis with data from complex surveys. Domain estimation. Small area estimation. Calibrated estimators. Model assisted approach in survey sampling.

Practicals

Estimation of parameters using sampling design based estimation procedures, unified theory of sampling, likelihood function under survey sampling, super population based approach of estimation, domain estimation, small area estimation. Categorical data analysis in the context of sample survey data. Exercises on robust estimation, regression analysis from sample survey data.

Suggested Readings

Cassel, C.M., Sarndal, C.E. and Wretman, J.H. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.

Hedayat, A.S. and Sinha, B.K. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.

Mukhopadhyay, P. 1967. *Theory and Methods of Survey sampling*. Prentice Hall of India.

Sarndal, C.E., Swensson, B. and Wretman, J. 1992. *Model Assisted Survey Sampling*. John Wiley.

AS 665 ADVANCED STATISTICAL METHODS FOR POPULATION GENETICS (2L+1P) II

Objective

This is an advanced course in Statistical Genetics that aims at describing some advanced level topics for students who wish to pursue research in Statistical Genetics. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject in plant and animal breeding.

Theory

UNIT I

Hardy-Weinberg law with multiple allelic systems, auto-tetraploids and self-sterility alleles. Complex cases of selection with two or more loci.

UNIT II

Different approaches to study inbreeding process, methods of path co-efficient, probability and generation matrix. Fisher's approach to inbreeding. Stochastic process of gene frequency change, transition matrix approach using finite Markov chains, diffusion approximation. Steady decay and distribution of gene frequency. Probability of fixation of a gene. Conditional process - Markov chains and diffusion approaches. Distribution of time until fixation, random fluctuations in selection intensity, stationary distribution of gene frequency. Effective population size.

Practicals

Exercises on Multiple allelism, Auto-tetraploid, Self sterility, Diffusion approach to inbreeding coefficient, Generation matrix approach to inbreeding.

Suggested Readings

Crow, J.F. and Kimura, M. 1970. *An Introduction of Population Genetics Theory*. Harper and Row.

Jain, J. P. and Prabhakaran, V.T. 1994. *Population Genetics*. South Asian Publishers Pvt. Ltd.

Kempthorne, O. 1957. *An Introduction to Genetic Statistics*. The Iowa State University Press.

Li, C.C. 1982. *Population Genetics*. The University of Chicago Press.

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

AS 666 ADVANCED QUANTITAVE GENETICS (2L+1P) III

Objective

This is an advanced course in Quantitative Genetics that aims at describing some advanced level topics for students who wish to pursue research in Statistical Genetics. This course prepares students for undertaking research in this area. This also helps them for applications of this important subject in plant and animal breeding.

Theory

UNIT I

Prediction and estimation of genetic merit. Best linear unbiased prediction. Use of mixed model methodology in analysis of animal and plant breeding experiments. Newer reproductive technology and its effect in genetic evaluation of individual merit. Estimation of genetic parameters: problems relating to computational aspects of genetic variance components, parameter estimation in variance component models for binary response data.

UNIT II

Identification of genes with large effects, Use of molecular markers (RFLP, PCR-AFLP, RAPD and SSR), gene mapping and quantitative trait loci. Molecular manipulation for genetic variability.

UNIT III

Survival analysis and concept of censored observation in animal breeding. Phylogeny and analysis of molecular variance. Genetic diversity, Association mapping.

Practicals

Prediction and estimation of genetic merit. Best linear unbiased prediction. Use of mixed model methodology in analysis of animal and plant breeding experiments.

Suggested Readings

Balding, D.J., Bishop, M. and Cannigs, C. 2007. *Handbook of Statistical Genetics*. John Wiley

Crow, J.F. and Kimura, M. 1970. *An Introduction of Population Genetics Theory*. Harper and Row.

Ewens, W.J. 1979. *Mathematical Population Genetics*. Springer.

Falconer, D.S. 1985. *Introduction to Quantitative Genetics*. English Language Book, Longman, Essex.

Fisher, R.A. 1949. *The Theory of Inbreeding*. Oliver and Boyd.

Fisher, R.A. 1958. *The Genetical Theory of Natural Selection*. Dover Publication.

Haldane, J.B.S. 1932. *The Causes of Evolution*. Harper and Bros..

Jain, J.P. 1982. *Statistical Techniques in Quantitative Genetics*. Tata McGraw.

Kempthorne, O. 1957. *An Introduction to Genetic Statistics*. The Iowa State University Press.

Lerner, I.M. 1950. *Population Genetics and Animal Improvement*. Cambridge University Press.

Lerner, I.M. 1958. *The Genetic Theory of Selection*. John Wiley.

Li, C.C. 1982. *Population Genetics*. The University of Chicago Press.

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

Mather, K. and Jinks, J.L. 1982. *Biometrical Genetics*. Chapman and Hall.

Nagilaki, T. 1992. *Introduction to Theoretical Population Genetics*. Springer.

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

Searle, S.R. 1998. *Variance Components*. John Wiley.

Searle, S.R. 1971. *Linear Models*. John Wiley.

AS 667 FORECASTING TECHNIQUES (1L+1P)

Objective

The students would be exposed to concepts of forecasting techniques. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

UNIT I

Forecasting techniques with special reference to agriculture. Forecast based on time series data: exponential smoothing, Box - Jenkins approach and non-linear models. Forecast models using weather parameters, crop-weather relationships and their use in yield forecast. Forecast using plant characters.

UNIT II

Forecast surveys, between-year models (regression model, Markov chain probability model and group method of data handling) and within-year models. Agro-meteorological models: climatic water balance model and crop yield assessment. Forewarning of crop pests and diseases. Application of remote sensing techniques in forecasting. Use of ANN in forecasting.

Practicals

Fitting of forecast models using weather parameters. Time series analysis: plots, decomposition, stationarity tests, exponential smoothing. Univariate Box - Jenkins ARIMA models and seasonal ARIMA models. Forecast models using plant characters, Agrometeorological models for crop forecasting, Markov chain models and ANN models.

Suggested Readings

Box, G.E.P., Jenkins, G.M. and Reinsel, G.C. 1994. *Time Series Analysis: Forecasting and Control*. Pearson Education.

Brocklebank, J.C. and David, D.A. 1986. *SAS System for Forecasting Time Series, SAS Institute*. Ed. Clank, D.S., North Carolina.

Brockwell, P.J. and Davis, R.A. 1996. *Introduction to Time Series and Forecasting*. Springer Verlag.

Harvey, A. 1981. *Time Series Models*. Philip Allan, Oxford.

Makridakis, S., Wheelwright, S.C. and Hyndman, R.J. 1998. *Forecasting: Methods and Applications*. John Wiley.

Pankratz, A. 1983. *Forecasting with Univariate Box Jenkins Models: Concepts and Cases*. John Wiley.

AS 668 BAYESIAN INFERENCE IN SURVEY SAMPLING (1L+1P) III

Objective

The students would be exposed to the advanced concepts of Bayesian Inference in Survey Sampling. This course prepares students for undertaking research in this area.

Theory

UNIT I

Super population models in sample surveys. Stochastic parameter models. Bayes' linear predictor, Bayesian models with multi-stage sampling. Measurement error and small area estimation.

UNIT II

Time series approach in survey sampling. Dynamic Bayesian prediction, Kalman filter, empirical and hierarchical Bayes predictors. Robust linear prediction, Bayesian robustness.

Practicals

Stochastic parameter models, Bayes' linear predictor, Kalman filter, Empirical and Hierarchical Bayes predictors, Robust linear prediction.

Suggested Readings

Berger, J.O. 1993. *Statistical Decision Theory and Bayesian Analysis*. Springer.

Bolfarine, H. and Zacks, S. 1992. *Prediction Theory for Finite Population Sampling*. Springer.

Cassel, C.M., Sarndal, C.E. and Wretman, J.H. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.

Des Raj and Chandhok, P. 1998. *Sample Survey Theory*. Narosa Publishing House.

Ghosh, M. and Meeden, G. 1997. *Bayesian Method for Finite Population Sampling. Monograph on Statistics and Applied Probability*. Chapman and Hall.

Mukhopadhyay, P. 1998. *Theory and Methods of Survey Sampling*. Prentice Hall of India.

Rao, J. N. K. 2003. *Small Area Estimation*. John Wiley.

Sarndal, C.E., Swensson, B. and Wretman, J. H. 1992. *Model Assisted Survey Sampling*. Springer.