

**AGRICULTURAL STATISTICS  
TRIMESTER WISE LIST OF COURSES**

<b>I Trimester</b>			
		<b>L</b>	<b>P</b>
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 / EXPERIMENT	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 370	RECENT ADVANCES IN THE FIELD OF SPECIALIZATION	1	0
AS 691	SEMINAR	1	0
<b>II Trimester</b>			
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	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 370	RECENT ADVANCES IN THE FIELD OF SPECIALIZATION	1	0
AS 691	SEMINAR	1	0
<b>III Trimester</b>			
AS 503	BASIC SAMPLING & 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	INFERENCE 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 370	RECENT ADVANCES IN THE FIELD OF SPECIALIZATION	1	0
AS 691	SEMINAR	1	0

### **Core Courses**

**For (M. Sc.):** Within the discipline: AS 560, AS 561, AS 562, AS 563, AS 564, AS 565, AS 566 and AS 567.

**For (Ph. D.):** Within the discipline: 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 160 to AS 167 are core courses for M.Sc. (Ag. Statistics).

### **AS 501 BASIC STATISTICAL METHOD**

**2+1**

#### **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 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.

##### **UNIT - II**

Probability distributions: Binomial, Poisson, Negative binomial, Normal distributions and their applications. Concept of sampling distribution: t, chi-square and F distributions. Tests of significance based on normal, t, chi-square 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. Probit regression analysis by least squares and maximum likelihood methods. Confidence interval for sensitivity. Testing for heterogeneity.

##### **UNIT - IV**

Selection of variables. Validation of models. Introduction to multivariate analytical tools. Principal component analysis.

### **Practical**

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, Testing of hypothesis based on exact sampling distributions ~ chi square, t and F. Confidence interval. Estimation and point estimation of parameters of Binomial, Poisson and Normal distribution. Correlation and regression analysis. Fitting of orthogonal polynomial regression. Applications of dimensionality reduction and Discriminant function analysis. Non-parametric tests.

### **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., Calcutta.

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

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.

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.

## **AS 502 BASIC DESIGN OF EXPERIMENTS**

**2+1**

### **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, Randomized block design (RBD), Latin square design (LSD), Balanced incomplete block design, Resolvable block designs and their applications. Alpha design and Lattice design-concepts.

### **UNIT - II**

Randomization procedure, analysis and interpretation of results. Analysis of covariance. Missing plot technique and its application to RBD, LSD.

### **UNIT - III**

Factorial experiments (symmetrical as well as asymmetrical). Confounding in factorial experiments - application in  $2^n$  and  $3^n$  factorial experiments. Factorial experiments with control treatment.

### **UNIT - IV**

Groups of experiments. Split plot and Strip plot designs. Change-over design. Sampling in field experiments. Transformation of data. Response surfaces. Experiments with mixture.

### **Practical**

Uniformity trial data analysis, Formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD. Analysis of Covariance, Analysis of factorial experiments without and with confounding, 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 Design*. John Wiley and Sons Inc.
- Das, M. N. and Giri, N.C. 1986. *Design and Analysis of Experiments*. New Age International.
- Gomez and Gomez. 1984. *Statistical procedure for Agricultural Research*. Wiley-interscience.
- Panse, V.G. and Sukhatme P.V. 1967. *Statistical Method for Agricultural Workers*. ICAR Publication.
- Steel, H.G.D. and Torri, J.M. 1960. *Principal and Procedure of Statistics*. McGraw Hill, New York.

## **AS 503 BASIC SAMPLING AND NON-PARAMETRIC METHODS 2+1**

### **Objective**

This course is meant for students of agricultural sciences other than Statistics. The students would be exposed to non-parametric tests and basic sampling techniques. It would help them in applying non-parametric tests and understanding the concepts involved in planning and designing surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

### **Theory**

### **UNIT - I**

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.

### **UNIT - II**

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.

#### **Practical**

Exercises on various Non-parametric tests; Random sampling, Use of random number tables, Simple random sampling, Determination of sample size, Exercises on Inverse sampling, Stratified sampling, Cluster sampling and Systematic sampling, Estimation using Ratio and regression estimators, Estimation using Multistage design and Double sampling.

#### **Suggested Readings**

- Cochron, W.G. 1959. *Sampling Techniques*. John Wiley and Sons, New York.
- Murthy, M.N. 1958. *Sampling Theory and Methods*. Statistical Publishing Society, Calcutta,
- 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 Ashok, C. 1984. *Sampling Theory of Surveys with Applications*. Indian Society of Agricultural Statistics.

## **AS 550 MATHEMATICAL METHODS**

**4+0**

### **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 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 and 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. Vectors and vector spaces, Matrices, notations and operations, Transpose and inverse of matrix. Laws of matrix algebra. Eigen values and eigen vectors. Determinants - evaluation and properties of determinants, Application of determinants and matrices in solution of equation for economic analysis.

### **UNIT - IV**

Set theory: Set operations, Finite and infinite sets, Operations of set, Function defined in terms of sets. 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,, New Delhi.

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, New Delhi.

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

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

Priestley, H.A. 1985. *Complex Analysis*. Clarenton Press, Oxford.

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

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

Saxena, H.C. 2007. *Calculus of Finite Differences and Numerical Analysis*. S. Chand and Company, New Delhi.

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

Searle, S.R. 1982. *Matrix Algebra Useful for Statistics*. Wiley-Interscience Publication.

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

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

Thomas, George B. Jr. and Finney, Ross L. 1996. *Calculus*. Pearson Education, Inc.

Walsh, G.R. 1985. *An Introduction to Linear Programming*. John Wiley and Sons, New York.

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

## **AS 551 MATHEMATICAL METHODS IN STATISTICS**

**4+0**

### **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 nth root test, Raabe's test, Kummer's test, Gauss test. Absolute and conditional convergence. Riemann integration, concept of Lebesgue integration, Power series, Fourier, Laplace and Laplace -Steiltjes' transformation, Multiple integrals.

#### **UNIT - 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., New Delhi.
- Frank, A. 1962. *Schaum's Outline of Theory and Problems 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.
- Malik, S.C. and Arora, S. 1992. *Mathematical Analysis*. New Age International.
- Narayan, S. 1953. *A Text Book of Matrices*. S. Chand and Company, New Delhi.
- 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

2+0

### Objective

This is a fundamental course in Statistics. This course lays the foundation of probability theory, random variable, probability distribution, mathematical expectation, etc. which forms the basis of basic statistics. The students are also exposed to law of large numbers and central limit theorem. The students also get introduced to stochastic processes.

### 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  $\mathbb{R}$ .

### 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. Jensen, 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. 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 and Sons.
- Larson, Harold J. 1969. *Introudction to Probability Theory and Statistical Inference*, John Wiley and sons.
- Loeve, M. 1978. *Probability Theory*. Springer.
- Marek Fisz. 1963. *Probability Theory and Mathematical Statistics*. John Wiley and Sons.
- Pfeiffer, Paul E. 1990. *Probability for Applications*. Springer Verlag.
- 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.

## 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 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

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,  $\chi^2$  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.

## Practical

Fitting of discrete distributions and test for goodness of fit. Fitting of continuous distributions and test for goodness of fit. Computation of simple, multiple and partial correlation coefficient. Correlation ratio and intra-class correlation. Regression coefficients and regression equations. Fitting of Pearsonian curves. Analysis of association between attributes, categorical data.

## Suggested Readings

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

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

Hoel, P.G. 1971. *Introduction to Mathematical Statistics*. John Wiley and Sons, New York.

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 and Sons, New York.

**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 also exposed to correlation and regression, and order statistics and their distributions. 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,  $\chi^2$  and F distributions. Distribution of quadratic forms. Cochran's theorem. Tests for normality. Large sample tests. Tests of significance based on t,  $\chi^2$  and F distributions.

**UNIT - IV**

Order statistics: Distribution of  $r^{\text{th}}$  order statistics, Joint distribution of several order statistics and their functions, Marginal distributions of order statistics, Distribution of range, median etc.

**Practical**

Fitting of truncated distribution: Fitting of Non-central t,  $\chi^2$  and F distributions. Computation of Tests of significance based on t,  $\chi^2$  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, Calcutta.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. 2008. *Fundamentals of Statistics*, Vol. I. Atlantic Publishers, New Delhi.
- Hoel, P.G. 1971. *Introduction to Mathematical Statistics*. John Wiley and Sons, New York.
- Hogg, R.V. and Craig, T.T. 1995. *Introduction Mathematical Statistics*. Prentice-Hall.

- Huber, P.J. 1981. *Robust Statistics*. John Wiley.
- Johnson, N.L., Kotz, S. and Balakrishnan, N. 2000. *Continuous Univariate Distributions*. John Wiley.
- Johnson, N.L., Kotz, S. and Balakrishnan, N. 2000. *Discrete 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 and Sons, New York.
- 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

4+1

### Objective

This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testing of hypothesis. They would also be given the concepts of nonparametric and sequential test procedures 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  $\chi^2$ , 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.

**(Pre-requisite: AS 562)**

### Practical

Methods of estimation - Maximum Likelihood, Minimum  $\chi^2$  and Moments: Confidence Interval Estimation, 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. 1992. *Bayesian Inference in Statistical Analysis*. John Wiley.
- 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 and Sons, New York.
- 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, New York.
- Kendall, N.G. and Stuart, A. 1960. *Advanced Theory of Statistics*. Vol I. Charles Griffen and Co. Ltd., London.
- Kiefer, J.C. 1987. *Introduction to Statistical Inference*. Springer verlag, New York.
- Lehmann E.L. 1983. *Theory of Statistical Hypotheses*. John Wiley & Sons, New York.
- Lehmann, E.L. 1986. *Theory of Point Estimation*. John Wiley & Sons, New York.
- Mood, A.M., Graybill, F.A. and Boes, D.C. 1974. *Introduction to the Theory of Statistics*. McGraw Hill Book Co., New York.
- Randles, R.H. and Wolfe, D.S. 1979. *Introduction to the Theory of Nonparametric Statistics*. John Wiley.
- Rao, C.R. 1973. *Linear Statistical Inference and its Applications*. John Wiley and Sons, New York.
- Rohatgi, V.K. and Saleh, A.K. 2005. *An Introduction to Probability and Statistics*. John Wiley.
- Rohtagi, V.K. 1976. *An Introduction to Probability Theory and Mathematical Statistics*. Wiley Eastern Ltd., New Delhi.
- Rohtagi, V.K. 1984. *Statistical Inference*. John Wiley & Sons, New York.
- 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, New York.
- Wald, A. 2004. *Sequential Analysis*. Dover Publications.

## 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: Shape and size of plots and blocks. Elements of linear estimation. Analysis of variance and covariance.

### UNIT - II

Completely randomized, Randomized block and Latin square designs.

### UNIT - III

Factorial experiments, Confounding in symmetrical factorial experiments (2n and 3n series), Split plot and Strip-plot designs. Mutually orthogonal latin squares. Missing plot techniques. Graeco Latin squares.

### 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. Change-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.

## Practical

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 with missing data. Split plot and strip plot designs. Transformation of data. Analysis of resolvable designs. Fitting of response surfaces.

## 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.

*Design Resources Server*: [www.iasri.res.in/design](http://www.iasri.res.in/design).

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

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

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. Wiley, New York.

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

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

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*. Wiley, New York.

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

## **AS 565 SAMPLING TECHNIQUES**

**3+1**

### **Objective**

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

### **Theory**

#### **UNIT - I**

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.

### **Practical**

Determination of sample size and selection of sample, Simple random sampling, Stratified random sampling, Cluster sampling, Systematic sampling, Ratio and regression methods of estimation, 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 & Sons, New York.
- Hedayat, A.S. and Sinha, B.K. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.
- Kish, L. 1965. *Survey sampling*. John Wiley & Sons, Inc.
- Murthy, M.N. 1977. *Sampling Theory and Methods*. Statistical Publishing Society, Calcutta.
- 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 Ashok, 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



Correlations between relatives, Heritability, Repeatability and Genetic correlation. Response due to selection, Selection index and its applications in plants and animals improvement programmes, Correlated response to selection. Restricted selection index, Inbreeding and cross-breeding, Changes in mean and variance.

### **Practical**

Test for the single factor segregation ratios, homogeneity of the families with regard to single factor segregation. Detection and estimation of linkage parameter by different procedures. Estimation of genotypic and gene frequency from a given data. Hardy-Weinberg law. Estimation of changes in gene frequency due to systematic forces, Inbreeding coefficient, Genetic components of variation, Heritability and repeatability coefficient, Genetic correlation coefficient. Examination of effect of linkage, epistasis and inbreeding on mean and variance of metric traits. 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 of Population Genetics Theory*. Harper and Row, New York.

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

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

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

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

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, Edinburgh.

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, London.

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

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

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

## AS 567 APPLIED MULTIVARIATE ANALYSIS

2+1

### 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. Tests of hypothesis about mean vector.

#### UNIT - II

Wishart distribution, Hotelling's  $T^2$  and Mahalanobis'  $D^2$  statistics, Null distribution of Hotelling's  $T^2$ . Rao's U statistics and its distribution. Wilks'  $\lambda$  criterion and statement of its properties. Concepts of discriminant analysis, Computation of linear discriminant function, Classification between  $k$  ( $\geq 2$ ) multivariate normal populations based on LDF and Mahalanobis  $D^2$ .

#### UNIT - III

Test of hypothesis on means, Multivariate analysis of variance and covariance, Cluster analysis, Classification by linear discriminant function, Canonical correlations, Principal components, Factor analysis, multi-dimensional scaling and Correspondence Analysis. Hierarchical clustering.

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

### Practical

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, London.
- 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

2+1

### Objective

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

### Theory

#### UNIT - I

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 leastsquares 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.

### Practical

Study of single equation linear regression models: Maximum likelihood and ordinary least-squares methods of estimation, Statistical inference in linear regression. Generalized least squares method of estimation, Heteroscedasticity, Auto-correlation, Distributed lag models. Study of 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 and Sons.
- 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.
- 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 and Sons, New York.
- Verbeek, M. 2008. *A Guide to Modern Econometrics*. John Wiley.

## **AS 569 PLANNING OF SURVEYS / EXPERIMENTS**

**2+1**

### **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.

### **Practical**

Designing of schedules and instruction manuals for conducting surveys, 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, Experiments on cultivators' fields. Intercropping and agro forestry experiments; Long-term and rotational experiments.

**(Pre-requisite: AS 502, AS 503 or AS 564, AS 565)**

### **Suggested Readings**

- Bansil, P.C. 2002. *Agricultural Statistics*. CBS Publishers.
- Cochran, W.G. and Cox, G.M. 1957. *Experimental Design*. John Wiley and Sons Inc.
- 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 and Gomez. 1984. *Statistical procedure for Agricultural Research*. Wiley-interscience.
- Murthy, M.N. 1977. *Sampling Theory and Methods*. Statistical Publishing Society, Calcutta.
- Panse, V.G. and Sukhatme P.V. 1967. *Statistical Method for Agricultural Workers*. ICAR Publication.
- Raut, K.C. and Singh, D. 1976. *Methods of Collection of Agricultural Statistics in India*. IASRI (ICAR), New Delhi.
- 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 Torri, J.M. 1960. *Principal and Procedure of Statistics*. McGraw Hill, New York.
- Sukhatme, P.V. and Panse, V.C. 1951. *Crop Surveys in India*. Jour. Ind. Soc.
- 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**

**2+1**

### **Objective**

This is an advanced course in Statistical Methods 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, Like 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 modeling.

### **UNIT - IV**

Compartmental modeling - First and second order input-output systems, Dynamics of a multivariable system.

**(Pre-requisite: AS 550)**

### **Practical**

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, London.
- Godfrey, K. 1983. *Compartmental Models and their Applications*. Academic Press.
- Ratkowsky, D.A. 1983. *Nonlinear Regression Modeling: 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 BIOINFORMATICS**

**3+1**

### **Objective**

Bioinformatics is a new emerging area. It is an integration of Statistics, Computer applications and Biology. The trained manpower in the area of Bioinformatics is required for meeting the new challenges in teaching and research in the discipline of Agricultural Sciences. This course is meant to train the students on concepts of basic biology, statistical techniques and computational techniques for understanding bioinformatics principals.

### **Theory**

#### **UNIT - I**

Basic Biology: Proteins and enzymes, genes, gene structures, gene expression and regulation, Molecular tools, nucleotides, nucleic acids, Markers, bioenergetics. Structural and functional genomics: Organization and structure of genomes, genome mapping, assembling of physical maps, strategies and

techniques for genome sequencing and analysis. Single nucleotide polymorphism, expressed sequence tag.

### **UNIT - II**

Computing techniques: Languages useful for browsing biological databases on web; Computer networks – Internet, World wide web, Web browsers – EMBnet, NCBI: Databases pertaining to Nucleic acid sequences, protein sequences, Genome and Proteome: Searching sequence databases, Structural databases.

### **UNIT - III**

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

### **UNIT - IV**

Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis, Approaches to EST analysis; Pairwise alignment techniques: Comparing two sequences, PAM and BLOSUM, Global alignment (The Needleman and Wunsch algorithm), Local Alignment (The Smith-Waterman algorithm), Dynamic programming, Pairwise database searching: Sequence analysis– BLAST and other related tools, Different methods of Multiple sequence alignment, Searching databases with multiple alignments; Alignment Scores, Design and Analysis of microarray experiments.

### **Practical**

Gene expression and regulation, Markers, Genome mapping, Genome sequencing and analysis, Classification techniques, Cluster analysis, PCA and PCoA, Estimation and Testing of Hypothesis, Analysis of microarray data, Programming languages in Bioinformatics, Web browsers – NCBI & TIGR, Nucleotide and protein databases, BLAST, Protein structures.

### **Suggested Readings**

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

Arthur, M. L. 2002. *Introduction to Bioinformatics*. Oxford University Press.

Baldi, P., Brunak S. 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.

Bergeron, B.P. 2002. *Bioinformatics Computing*. Prentice Hall.

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

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: An Introduction: Statistics for Biology and Health*. Springer.

- Hunt, S. and Livesy, F. 2000. *Functional Genomics: A Practical Approach: The Practical Approach Series, 235*. Oxford University Press.
- James, D.T. 2001. *Beginning Perl for Bioinformatics*. O'Reilly and Associates.
- Jones, N.C. and Pevzner, P.A. 2004. *An Introduction to Bioinformatics Algorithms*. MIT Press.
- Koski, T. and 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.
- 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.
- 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, Inc.

## **AS 572 STATISTICAL QUALITY CONTROL**

**2+0**

### **Objective**

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agribusiness and agro-processing industries. This course would enable the students to have an idea about the statistical techniques used in quality control. Students who do not have sufficient background of Statistical Methods.

### **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 of India, New Delhi.

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

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

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

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

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

## **AS 573 DEMOGRAPHY**

**2+0**

### **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, Inc.

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

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**

**1+1**

### **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 prepare 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.

**(Pre-requisite: AS 564)**

## Practical

Overview of MS-EXCEL, SAS, SPSS, SPBD Release 1.0, SPFE 1.0, Block Designs, Analysis of fractional replications of factorial experiments, Analysis of asymmetrical factorials and block designs with factorial structure, Analysis of Latin Square Type Designs, Analysis of group divisible designs, Analysis of triangular designs, Lattice Designs, Analysis of second order response surface designs.

## Suggested Readings

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

Cox, D.R. 1958. *Planning of Experiments*. John Wiley and Sons, New York.

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

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

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

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

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

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

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

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

Nigam, A.K. and Gupta, V.K. 1979. *HandBook on Analysis of Agricultural Experiments*. IASRI Publication, New Delhi.

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

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

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

Searle, S.R. 1971. *Linear Models*. John Wiley and Sons, New York.

<http://www.iasri.res.in/design>

<http://www.iasri.res.in/iasriwebsite/DESIGNOFEXPAPPLICATION/Electronic-Book/index.htm>

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 prepare students 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,  $\pi$ PS 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.

**(Pre-requisite: AS 565)**

### **Practical**

Sampling with varying probability, Ordered and un-ordered estimators, Sampling strategies due to Horvitz-Thompson, Midzuno-Sen, Rao-Hartley-Cochran and  $\pi$ PS sampling: Procedures such as Brewer, Durbin and Sampford etc., Imperfect frames, Randomized Response Technique.

### **Suggested Readings**

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

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

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

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*. I.A.S.R.I., New Delhi.

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

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

### **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**

Genetic load, Random genetic drift, Effect of finite population size, Theory of path coefficients. Regular system 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.

**(Pre-requisite: AS 566)**

## **Practical**

Genetic Load and Random Genetic Drift, Effect of finite Population Size, Theory of path coefficients, Multiple allelism in continuous variation, Sex-linked genes, Maternal effects, Analysis of GxE interaction, Measurement of stability and adaptability, Diallel and partial diallel crosses - construction and analysis.

### **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 of Population Genetics Theory*. Harper and Row, New York.

Crow, J.F. and Kimura, M. 1970. *Introduction to Population Genetics*.

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

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, Longman, Essex, England.

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

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

- 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., New Delhi.
- 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, Edinburgh.
- 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, London.
- Mather, K. 1951. *The Measurement of Linkage in Heredity*. Methuen, London.
- 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., New Delhi.

## AS 603 REGRESSION ANALYSIS

1+1

### Objective

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

### Theory

#### UNIT - I

Simple and Multiple linear regressions: Least squares fit, Properties and examples. Polynomial regression: Use of orthogonal polynomials. Analysis of multiple regression models, estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation.

#### UNIT - II

Selection of variables, adequacy and validation of models. Use of dummy variables, regression with ordinal data. Introduction to non-parametric regression. Logistic regression.

#### UNIT - III

Regression diagnostics - non-normal errors, non-constant error variances, non independent observations, influential observations (outliers), non-linearity of the model, multicollinearity in the data. Remedial measures - regression under non-normal errors, transformation of data, generalized least-squares, robust regression, ridge regression, Regression using principal components. Model over-fitting, model under-fitting.

## Practical

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

## Suggested Readings

Barnett, V. and Lewis, T. 1984. *Outliers in Statistical Data*. Wiley Ltd., New York.

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 and Sons Inc., New York.

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

## AS 604 LINEAR MODELS

2+0

### 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, New York.

- 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, New Delhi.
- Rao, C. R. 2001. *Linear Inference and its Application*. Wiley Eastern.
- Searle, S. R. 1998. *Variance Components*. John Wiley and Sons, New York.
- Searle, S.R. 1971. *Linear Models*. John Wiley and Sons, New York.
- Seber, G.A. F. 1996. *The linear Hypothesis: A general theory*. Griffin, Charles and Co. Ltd.
- Sheffe, H. 1999. *Analysis of Variance*. John Wiley and Sons, New York.

## **AS 605 ADVANCED STATISTICAL INFERENCE**

**1+1**

### **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 in basic statistics that would help them in 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. The 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.

### **Practical**

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**



- 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 Theoretic 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.
- Kale, B.K. 1999. *A First Course on Parametric Inference*. Narosa Publication.
- Prakasa Rao, B.L.S. 1983. *Nonparametric Functional Estimation*. Academic Press.
- Hogg, R.V. and Craig, A.T. 1999. *Introduction to Mathematical Statistics*. Prentice Hall.
- 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 Balakrishnana, 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.
- Bishop, Y.M.M., Fienberg, S.E. and Holland, P.W. 1975. *Discrete Multivariate Analysis Theory and Practice*. MIT Press, Cambridge.

## **AS 606 OPTIMIZATION TECHNIQUES**

**1+1**

### **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.

### **Practical**

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

### **Suggested Readings**

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

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**

**3+0**

### **Objective**

This is a course on Stochastic Processes 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 this area. This also helps prepare students 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-Furry 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. *Finite Markov Processes*. John Wiley.
- Bailey, N.T.J. 1964. *Elements of Stochastic Processes with Applications to the Natural Sciences*. Wiley Eastern Ltd., New Delhi.
- 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, London.
- Draper, N.R. and Smith, H. 1981. *Applied Regression Analysis*. Wiley Eastern Ltd., New Delhi.

- France, J. and Thornley, J.H.M. 1984. *Mathematical Models in Agriculture*. Butterworths, London.
- 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., New Delhi.
- 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 Modeling: 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**

**2+1**

### **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, ClustalW 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, Modeling 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.

**(Pre-requisite: AS 571)**

### **Practical**

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, Analysis of multiple DNA or protein sequences, Computationally intensive methods, Multiple Hypothesis testing, Phylogenetic tree estimation, Analysis of SNPs and Haplotypes.

### **Suggested Readings**

- 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 Algorithms*. The MIT Press.
- 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 2+1**

### **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. This also helps prepare students for applications of this important subject to agricultural sciences.

### **Theory**

#### **UNIT - I**

General properties and analysis of block designs. Balancing criteria. M-associate 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.

### **Practical**

Analysis of Block Designs, Analysis of PBIB designs, Analysis of Lattice designs, Analysis of designs for two way elimination of heterogeneity designs, 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, Bombay.

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>
- Dey, A. 1986. *Theory of Block Designs*. Wiley Eastern Ltd., New Delhi.
- Dey, A. and Mukerjee, R. 1999. *Fractional Factorial Plans*. John Wiley.
- Hall, M. Jr. 1986. *Combinatorial Theory*. John Wiley.
- Hedayat, A.S., Sloane, N.J.A. and Stufken, J. 1999. *Orthogonal Arrays: Theory and Applications*. Springer.
- John, J.A. and Quenouille, M.H. 1977. *Experiments: Design and Analysis*. Charles and Griffin Co. Ltd., London.
- 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, New Delhi.
- 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*. I.A.S.R.I., New Delhi
- Parsad, R., Gupta, V.K., Batra, P.K., Satpati, S.K. and Biswas, P. 2007. *Monograph on  $\alpha$ -designs*. IASRI, New Delhi.
- 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 2+1**

### **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.

### **Practical**

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

### **Suggested Readings**

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

Dey, A. and Mukerjee, R. 1999. *Fractional Factorial plans*. Wiley, New York.

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

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

## **AS 663 ADVANCED THEORY OF SAMPLE SURVEYS**

**2+1**

### **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.

### **Practical**

Unbiased ratio and regression type estimators, Multivariate ratio and regression methods of estimation. Ranked set sampling. Systematic sampling in two dimensions. Softwares 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*. North Holland.

Cochran, W.G. 1959. *Sampling Techniques*. John Wiley and Sons, New York.

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 of India, New Delhi.

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

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 and Sons, New York.

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, New Delhi.

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

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

## **AS 664 INFERENCE ASPECTS OF SURVEY SAMPLING AND ANALYSIS OF SURVEY DATA**

**2+1**

### **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.

### **Practical**

Sampling design based estimation, Unified theory of sampling, Existence under restricted condition, 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, 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, New Delhi.

Sarndal, C.E., Swensson, B. and Wretman, J. 1992. *Model assisted survey sampling*. John Wiley and Sons, New York.

## **AS 665 ADVANCED STATISTICAL METHODS FOR POPULATION GENETICS 2+1**

### **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.

### **Practical**

Multiple allilism systems, 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, New York.

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

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., New Delhi.

## **AS 666 ADVANCED QUANTITATIVE GENETICS**

**2+1**

### **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 prepare students 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.

### **Practical**

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**

Agresti. *Categorical Data analysis*.

Balding, et al. *Handbook of Statistical Genetics*.

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

- Ewens, W.J. 1979. *Mathematical Population Genetics*. Springer.
- Falconer, D.S. 1985. *Introduction to Quantitative Genetics*. English Language Book, Longman, Essex, England.
- Fisher, R.A. 1949. *The Theory of Inbreeding*. Oliver and Boyd, Edinburgh.
- Fisher, R.A. 1958. *The Genetical Theory of Natural Selection*. Dover Publication, New York.
- Haldane, J.B.S. 1932. *The Causes of Evolution*. Harper and Bros., London.
- 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. London.
- 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., New Delhi.
- Searle, S.R. 1998. *Variance Components*. John Wiley and Sons, New York.
- Searle, S.R. 1971. *Linear Models*. John Wiley and Sons, New York.

## **AS 667 FORECASTING TECHNIQUES**

**1+1**

### **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. Applications of remote sensing techniques in forecasting. Use of ANN in forecasting.

### **Practical**

Forecast models using weather parameters, Time series analysis-plots, decomposition, stationarity tests. Exponential smoothing models, 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, Delhi.

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, New York.

Harvey, A. 1981. *Time series models*. Philip Allan, Oxford/Also 1984 publication by Heritage Publishers, Delhi.

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

Pankratz, A. 1983. *Forecasting with univariate Box Jenkins models: concepts and cases*. John Wiley, New York.

## **AS 668 BAYESIAN INFERENCE IN SURVEY SAMPLING**

**1+1**

### **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.

### **Practical**

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.

**AS 370 RECENT ADVANCES IN THE FIELD OF SPECIALISATION 1+0**

**Objective**

To familiarize the students with the recent advances in the areas of their specialization to prepare them for undertaking research.

**UNIT - I**

Recent advances in the field of specialization - sample surveys / design of experiments/ statistical genetics/ statistical modeling, etc. will be covered by various speakers from the Institute as well as from outside the Institute in the form of seminar talks.

**AS 691 SEMINAR**

**1+0**