TAMIL NADU VETERINARY AND ANIMAL SCIENCES UNIVERSITY

U.O.No.60021/R.I/Spl.BOM-73/2011
No.3912/R.I/Spl.BOM-73-4/50-14-BS-3/2011

Office of the Registrar,
Madhavaram Milk Colony, Chennai-51.

Dated: 15.4.2011.

PROCEEDINGS

Sub: TANUVAS – Board of Management – Seventy Third Special Meeting held on 17.3.2011 – Starting of the Post-graduate degree programme in Bio-Statistics and the syllabus for the course – Approved – Orders – Issued.

-oOo-

ORDER:

The Board of Management in its Seventy Third Special Meeting held on 17.3.2011 considered the recommendation of the 50th Meeting of the Academic Council held on 9.3.2011 and approved the starting of the Post-graduate degree programme in Bio-Statistics and the syllabus for the course as detailed in the annexure with the following three types of degrees, in the Basic Sciences faculty of the University:

1) M.V.Sc. Bio-Statistics for B.V.Sc. / B.V.Sc. & A.H. graduates;

2) M.F.Sc., in Bio-Statistics for B.F.Sc., graduates; and

3) M.Sc. in Bio-Statistics for B.Sc., (Agri), B.Sc.(Horti), B.Tech.(FPT), B.Tech. (Dairy Tech.) and other Graduates of life Sciences with the same set of courses and the syllabus for the course. However, the project work should be carried out in the respective discipline.

2) Section 'C', Registrar's Office, TANUVAS shall take necessary action in the matter.

/BY ORDER OF THE VICE-CHANCELLOR/

REGISTRAR.

Encl: Annexure.

To
Section 'C', Registrar's Office, TANUVAS.
Cc: The Finance Officer, TANUVAS.
Cc: Section 'E', Registrar's Office, TANUVAS.
Cc: Stock File/U.S.O File/Spare-2.

ANNEXURE

SYLLABUS FOR THE NEW PG PROGRAMME IN BIO-STATISTICS

(with the new restructured syllabus by ICAR in 2009)

Preamble

The subject of statistics has a wide range of applications in the disciplines of physical, social, agricultural, animal, fisheries, medical, biological and other life sciences, forming a backbone and integrated component of any research and emerging as an important branch of sciences to help in strengthening research in all these disciplines. The research problems of these sciences are altogether different from those of others, because in these sciences there would always be a scarcity of resources and the experimentation would be of a longer duration. Therefore, the students doing their PG programme in Statistics need to be trained with greater emphasis on Bio-statistical techniques. The courses covered in this discipline should cater to the requirements of the students in a way that they learn the statistical techniques needed to carry out analysis of their unique data. Hence, while designing curricula in bio-statistics, in particular for these sciences, due care has to be taken to cover all statistical techniques required especially for life sciences. Currently, M.Sc. in bio-statistics is offered only at Indian Veterinary Research Institute, Izatnagar, although limited no. of courses of bio-statistics are offered in the curriculum of Agricultural Statistics / Statistics in SAUs and DUs.

For the reason that the course curricula in the discipline of biological sciences should meet the demands of biological research in emerging areas and since there is a huge gap between the demand and supply of trained manpower in this discipline in the country, it is necessary that TANUVAS, the leading institution in the country, starts a PG programme in Bio-Statistics for not only those specialising in veterinary and animal sciences and fisheries sciences, but also of other biological and life sciences to meet the challenges. Hence, based on the recommendation of ICAR on restructuring the syllabus and curricula for PG degree on Statistics, Agricultural Statistics, Bio-statistics and Computer Applications, a new PG programme – MVSc / MSc in Bio-Statistics is hereby proposed to be introduced.

Admission requirement and eligibility

MVSc Bio-Statistics

Graduates with BVSc / BVSc & AH degree

MSc Bio-Statistics

Graduates with BFSc, BSc(Ag), BSc(Hort), BTech (FPT), BTech (Dairy Tech) or any degree in life / biological sciences

The eligibility marks in the qualifying examination for admission will be minimum marks / GPA as prescribed in TANUVAS Postgraduate Regulations 2009.

Annual intake The annual intake and break up to different degrees will be as specified by TANUVAS from time to time.

Academic Regulations

As per TANUVAS Academic Regulations for Postgraduate programmes 2009

Minimum Credit Requirements

Subject	MVSc in Bio-Statistics	MSc in Bio-Statistics
Major	36	36
Minor	09	09
Supporting	05	05
Seminar	01	01
Research	10	10
Total Credits	**61**	**61**
Compulsory Non Credit Courses		

Non-Credit Compulsory Courses: Although six courses (PGS 601 to 606) are of general nature and compulsory for MVSc programme in TANUVAS, the students registering for MVSc / MSc in Bio-

Statistics may be exempted from PGS 604 Basic Concepts in Laboratory Techniques 0+1, as this course is not relevant to these Master's programme and instead a course PGS 607 Livestock production – Concepts and procedures (2+1) may be offered, as done for MSc in Agricultural Statistics (Agricultural production – Concepts and procedures).

Course Structure

CODE	COURSE TITLE	CREDITS
Major Courses		
BST 660	Probability theory	2+0
BST 661	Statistical methods	2+1
BST 662	Statistical inference	2+1
BST 663	Multivariate analysis	2+1
BST 664	Design of experiments	2+1
BST 665	Sampling techniques	2+1
BST 666	Statistical genetics	2+1
BST 667	Regression analysis	1+1
BST 668	Statistical computing	1+1
BST 669	Survival models in bio-statistics	2+1
BST 670	Actuarial statistics	2+0
BST 671	Stochastic processes	2+0
BST 672	Demographic techniques in bio-statistics	2+1
BST 673	Econometrics and operational research	2+1
BST 674	Optimization techniques	1+1
Minor Courses		
MCA 601	Computers fundamentals and programming	2+1
MCA 602	Introduction to networking and internet applications	1+1
MCA 652	Numerical analysis	2+0
AHS 602	Computer applications in animal sciences	1+1
Supporting Courses		
BST 651	Basic mathematics – I	3+0
BST 652	Basic mathematics - II	2+0
Seminar and research		
BST 691	Master's seminar	1+0
BST 699	Master's research	0+10

Note: Course Nos. BST 660 to BST 669 are compulsory.

Current Faculty Strength and Need for Hiring Adjunct Faculty

The Dept. of Animal Husbandry Statistics and Computer Applications, Madras Veterinary College proposing to offer PG Programme on MVSc / MSc – Bio-Statistics has the following faculty strength, along with the courses they can handle:

Faculty	Sanctioned Strength	No. in Position	Faculty from other Dept. working	Specialisation	Course(s) he / she can handle
Professor	One	One	Nil	1. Animal Husbandry Economics	1. BST 667 Regression analysis 1+1 2. BST 669 Survival models in bio-statistics 2+1 3. BST 673 Econometrics and operational research 2+1 4. BST 674 Optimization techniques 1+1 5. MCA 602 Introduction to networking and internet applications 1+1

Faculty	Sanctioned Strength	No. in Position	Faculty from other Dept. working	Specialisation	Course(s) he / she can handle
Associate Professor	One	One	Two	1. Agricultural Economics (Econometrics)	1.BST 660 Probability theory 2+0 2.BST 661 Statistical methods 2+1 3.BST 664 Design of experiments 2+1 4.BST 665 Sampling techniques 2+1 5.MCA 652 Numerical analysis 2+0
				2. Animal Husbandry Economics	1.BST 670 Actuarial statistics 2+0 2.BST 672 Demographic techniques in bio-statistics 2+1 3.AHS 602 Computer applications in animal sciences 1+1
				3. Meat Science & Technology	-
Assistant Professor	Three	Nil	Nil	-	-

Of the major, minor and supporting courses listed for the programme, there are a few courses which need faculty resources from outside the Dept. as listed below:

Course	Faculty from outside
BST 651 Basic mathematics – I 3+0	This course can be handled by the faculty specialised in Mathematics available at IFDT, TANUVAS.
BST 652 Basic mathematics – II 2+0	
BST 666 Statistical genetics 2+1	This course can be handled by the faculty of Animal Genetics and Breeding, MVC, TANUVAS.
BST 662 Statistical inference 2+1	Faculty needs to be hired **from outside the University** for these courses.
BST 668 Statistical computing 1+1	
BST 671 Stochastic processes 2+0	
MCA 601 Computers fundamentals and programming 2+1	

Financial commitment

As the course teachers for the four courses viz., BST 662 Statistical inference 2+1, BST 668 Statistical computing 1+1, BST 671 Stochastic processes 2+0 and MCA 601 Computers fundamentals and programming 2+1 are to be hired from outside the University. Apart from these courses, the University shall decide from time to time course teachers to be hired for any other course not provided above. The faculty may be hired form the University of Madras (Ramanujam Institute of Advanced Studies in Mathematics and Department of Statistics), Central Institute of Brackishwater Aquaculture (Social Sciences Division), Anna University (Dept. of Mathematics), IIT Madras (Dept. of Mathematics), Indian Statistical Institute Chennai Centre, etc., to whom honorarium needs to be paid The amount to be paid as honorarium shall be as decided by the University from time to time.

Syllabus

BST 660 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.

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

Classification of Stochastic Processes, Examples. Markov Chain and classification of states of Markov Chain.

Suggested Readings

Ash RB. 2000. *Probability and Measure Theory*. 2nd Ed. Academic Press.
Billingsley P. 1986. *Probability and Measure*. 2nd Ed. John Wiley.
Capinski M & Zastawniah. 2001. *Probability Through Problems*. Springer.
Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.
Feller W. 1972. *An Introduction to Probability Theory and its Applications*. Vols. I., II. John Wiley.
Loeve M. 1978. *Probability Theory*. 4th Ed. Springer.
Marek F. 1963. *Probability Theory and Mathematical Statistics*. John Wiley.
Rohatgi VK & Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. John Wiley.

BST 661 STATISTICAL METHODS 2+1

Objective

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

Descriptive statistics: probability distributions: Discrete probability distributions ~ Bernoulli, Binomial, Poisson, Negative-binomial, Geometric and Hyper Geometric, uniform, multinomial ~ Properties of these distributions and real life examples. Continuous probability distributions ~ rectangular, exponential, Cauchy, normal, gamma, beta of two kinds, Weibull, lognormal, logistic, Pareto. Properties of these distributions. Probability distributions of functions of random variables.

UNIT II

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

UNIT III

Concepts of random vectors, moments and their distributions. Bivariate Normal distribution - marginal and conditional distributions. Distribution of quadratic forms. Cochran theorem. Correlation, rank correlation, correlation ratio and intra-class correlation. Regression analysis, partial and multiple correlation and regression.

UNIT IV

Sampling distribution of correlation coefficient, regression coefficient, correlation ratio, intra class correlation coefficient. Categorical data analysis - loglinear models, Association between attributes. Variance Stabilizing Transformations.

UNIT V

Order statistics, distribution of r-th order statistics, joint distribution of several order statistics and their functions, marginal distributions of order statistics, distribution of range, median, etc.

Practical

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

Suggested Readings

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

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

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

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

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

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

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

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

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

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

BST 662 STATISTICAL INFERENCE 2+1

Objective

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

decision theory.

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

Practical

Methods of estimation - Maximum Likelihood, Minimum χ^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 GEP & Tiao GC. 1992. *Bayesian Inference in Statistical Analysis*. John Wiley.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

BST 663 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

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

UNIT II

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

UNIT III

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

UNIT IV

Path analysis and computation of path coefficients, introduction to multidimensional scaling, some theoretical results, similarities, metric and non metric scaling methods. Concepts of analysis of categorical data.

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 TW. 1984. *An Introduction to Multivariate Statistical Analysis*. 2nd Ed. John Wiley.
Arnold SF. 1981. *The Theory of Linear Models and Multivariate Analysis*. John Wiley.
Giri NC. 1977. *Multivariate Statistical Inference*. Academic Press.
Johnson RA & Wichern DW. 1988. *Applied Multivariate Statistical Analysis*. Prentice Hall.
Kshirsagar AM. 1972. *Multivariate Analysis*. Marcel Dekker.
Muirhead RJ. 1982. *Aspects of Multivariate Statistical Theory*. John Wiley.
Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.
Rencher AC. 2002. *Methods of Multivariate Analysis*. 2nd Ed. John Wiley.
Srivastava MS & Khatri CG. 1979. *An Introduction to Multivariate Statistics*. North Holland.

BST 664 DESIGN OF EXPERIMENTS 2+1

Objective

Design of Experiments provides the statistical tools to get maximum information from least amount

of resources. This course is meant to expose the students to the basic principles of design of experiments. The students would also be provided with mathematical background of various basic designs 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

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

Factorial experiments, confounding in symmetrical factorial experiments (2n and 3n series), partial and total confounding, fractional factorials, asymmetrical factorials.

UNIT VI

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

Practical

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

Suggested Readings

Chakrabarti MC. 1962. Mathematics of Design and Analysis of Experiments. Asia Publ. House.
Cochran WG & Cox DR. 1957. Experimental Designs. 2nd Ed. John Wiley.
Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.
Dey A & Mukerjee R. 1999. Fractional Factorial Plans. John Wiley.
Dey A 1986. Theory of Block Designs. Wiley Eastern.
Hall M Jr. 1986. Combinatorial Theory. John Wiley.
John JA & Quenouille MH. 1977. Experiments: Design and Analysis. Charles & Griffin.
Kempthorne, O. 1976. Design and Analysis of Experiments. John Wiley.
Khuri AI & Cornell JA. 1996. Response Surface Designs and Analysis. 2nd Ed. Marcel Dekker.
Kshirsagar AM 1983. A Course in Linear Models. Marcel Dekker.
Montgomery DC. 2005. Design and Analysis of Experiments. John Wiley.
Raghavarao D. 1971. Construction and Combinatorial Problems in Design of Experiments. John Wiley.

Searle SR. 1971. Linear Models. John Wiley.
Street AP & Street DJ. 1987. Combinatorics of Experimental Designs. Oxford Science Publ.
Design Resources Server. Indian Agricultural Statistics Research Institute (ICAR), New Delhi-110012, India. www.iasri.res.in/design.

BST 665 SAMPLING TECHNIQUES 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Sampling with varying probabilities with and without replacement, PPS sampling, Cumulative method and Lahiri's method of selection, Horvitz-29 Thompson estimator, Ordered and unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran. Inclusion probability proportional to size sampling, PPS systematic sampling, Multistage sampling with unequal probabilities, Self weighting design PPS sampling.

UNIT V

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

Practical

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

Suggested Readings

Cassel CM, Sarndal CE & Wretman JH. 1977. Foundations of Inference in Survey Sampling. John Wiley.
Chaudhari A & Stenger H. 2005. Survey Sampling Theory and Methods. 2nd Ed. Chapman & Hall.
Chaudhari A & Voss JWE. 1988. Unified Theory and Strategies of Survey Sampling. North Holland.
Cochran WG. 1977. Sampling Techniques. John Wiley.
Hedayat AS & Sinha BK. 1991. Design and Inference in Finite Population Sampling. John Wiley.
Kish L. 1965. Survey Sampling. John Wiley.
Murthy MN. 1977. Sampling Theory and Methods. 2nd Ed. Statistical Publ. Society, Calcutta.
Raj D & Chandhok P. 1998. Sample Survey Theory. Narosa Publ.
Sarndal CE, Swensson B & Wretman J. 1992. Models Assisted Survey Sampling. Springer.
Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. Sampling Theory of Surveys with

Applications. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
Thompson SK. 2000. Sampling. John Wiley.

BST 666 STATISTICAL GENETICS 2+1

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

UNIT VI

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

Practical

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

Suggested Readings

Bailey NTJ. 1961. The Mathematical Theory of Genetic Linkage. Clarendon Press.
Balding DJ, Bishop M & Cannings C. 2001. Hand Book of Statistical Genetics. John Wiley.
Crow JF & Kimura M. 1970. An Introduction of Population Genetics Theory. Harper & Row.
Dahlberg G. 1948. Mathematical Methods for Population Genetics. Inter Science Publ.
East EM & Jones DF. 1919. Inbreeding and Outbreeding. J B Lippincott.
Ewens WJ. 1979. Mathematics of Population Genetics. Springer.
Falconer DS. 1985. Introduction to Quantitative Genetics. ELBL 31

Fisher RA. 1949. The Theory of Inbreeding. Oliver & Boyd.
Fisher RA. 1950. Statistical Methods for Research Workers. Oliver & Boyd.
Fisher RA. 1958. The Genetical Theory of Natural Selection. Dover Publ.
Kempthorne O. 1957. An Introduction to Genetic Statistics. The Iowa State Univ. Press.
Lerner IM. 1950. Population Genetics and Animal Improvement. Cambridge Univ. Press.
Lerner IM. 1954. Genetic Homeostasis. Oliver & Boyd.
Lerner IM. 1958. The Genetic Theory of Selection. John Wiley.
Li CC. 1982. Population Genetics. The University of Chicago Press.
Mather K & Jinks JL. 1977. Introduction to Biometrical Genetics. Chapman & Hall.
Mather K & Jinks JL. 1982. Biometrical Genetics. Chapman & Hall.
Mather K. 1949. Biometrical Genetics. Methuen.
Mather K. 1951. The Measurement of Linkage in Heredity. Methuen.
Narain P. 1990. Statistical Genetics. Wiley Eastern.

BST 667 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 and to provide a mathematical foundation behind these techniques and their applications in agricultural data.

Theory

UNIT I

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

UNIT II

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

UNIT III

Concepts of Least median of squares and its applications; Concept of multicollinearity, Analysis of multiple regression models, estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation.

UNIT IV

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

UNIT V

Introduction to non-linear models, nonlinear estimation: Least squares for nonlinear models.

Practical

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

Suggested Readings

Barnett V & Lewis T. 1984. *Outliers in Statistical Data*. John Wiley.
Belsley DA, Kuh E & Welsch RE. 2004. *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity*. John Wiley.
Chatterjee S, Hadi A & Price B. 1999. *Regression Analysis by Examples*. John Wiley.
Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
McCullagh P & Nelder JA. 1999. *Generalized Linear Models*. 2nd Ed. Chapman & Hall.

Montgomery DC, Peck EA & Vining GG. 2003. *Introduction to Linear Regression Analysis*. John Wiley.
Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

BST 668 STATISTICAL COMPUTING 1+1

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

Theory

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

UNIT II
ANOVA, regression and categorical data methods; model formulation, fitting, diagnostics and validation; Matrix computations in linear models. Analysis of discrete data.

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

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

Practical
Data management, Graphical representation of data, Descriptive statistics; General linear models ~ fitting and analysis of residuals, outlier detection; Categorical data analysis, analysis of discrete data, analysis of binary data; Numerical algorithms; Spatial modeling, cohort studies; Clinical trials, analysis of survival data; Handling missing data.

Suggested Readings

Agresti A. 2002. *Categorical Data Analysis*. 2nd Ed. John Wiley.
Everitt BS & Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.
Geisser S. 1993. *Predictive Inference: An Introduction*. Chapman & Hall.
Gelman A & Hill J. 2006. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge Univ. Press.
Gentle JE, Härdle W & Mori Y. 2004. *Handbook of Computational Statistics - Concepts and Methods*. Springer.
Han J & Kamber M. 2000. *Data Mining: Concepts and Techniques*. Morgan.
Hastie T, Tibshirani R & Friedman R. 2001. *The Elements of Statistical Learning: Data Mining, Inference and Prediction*. Springer.
Kennedy WJ & Gentle JE. 1980. *Statistical Computing*. Marcel Dekker.
Miller RG Jr. 1986. *Beyond ANOVA, Basics of Applied Statistics*. John Wiley.
Rajaraman V. 1993. *Computer Oriented Numerical Methods*. Prentice-Hall.
Ross S. 2000. *Introduction to Probability Models*. Academic Press.
Ryan BF & Joiner BL. 1994. *MINITAB Handbook*. 3rd Ed. Duxbury Press.
Simonoff JS. 1996. *Smoothing Methods in Statistics*. Springer.
Snell EJ. 1987. *Applied Statistics: A Handbook of BMDP Analyses*. Chapman & Hall.
Thisted RA. 1988. *Elements of Statistical Computing*. Chapman & Hall.
Venables WN & Ripley BD. 1999. *Modern Applied Statistics With S-Plus*. 3rd Ed. Springer.

BST 669 SURVIVAL MODELS IN BIO-STATISTICS 2+1

Objective
The course deals with study of survival times and their statistical properties along with the factors

affecting them.

Theory

UNIT I

Concept of survival data, definition and associated probability density function, survival function, hazard function, Censoring in survival time.

UNIT II

Estimation of survival function by life table analysis, Kaplien and Meirer Method. UNIT III

Survival and failure time distributions: family of exponential and Weibul models.

UNIT IV

Analytical and graphical method for choosing best fitted distribution, Parametric and non-parametric tests for comparison of survival functions.

UNIT V

Concomitant variables in lifetime distribution models, Cox-proportional hazard models, Cox-proportional hazard models with time dependent covariates.

Practical

Estimation of survival functions - life table analysis; Kaplan and Meirer Method. Estimation of survival functions in case of censored observations - life table method, Kaplan and Meirer method; Fitting of survival and failure time distributions: family of exponential and Weibul models (For uncensored and censored observations); Regression and Maximum Likelihood Method of fitting and choosing appropriate distribution to the survival times; Graphical method for choosing best fitted distribution, Parametric and Non-Parametric tests for comparison of survival functions; Parametric tests for comparison of survival functions in the presence of censored survival times; Non parametric tests for comparing survival functions in the presence of uncensored survival times; Concomitant variables in lifetime distribution models. Fitting of Cox-proportional hazard models.

Suggested Readings

Anderson B. 1990. *Methodological Errors in Medical Research*. Blackwell.

Armitage P & Berry G. 1987. *Statistical Methods in Medical Research*. Blackwell.

Collett D. 2003. *Modeling Survival Data in Medical Research*. Chapman & Hall.

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

Elandt-Johnson RC & Johnson NL. 1980. *Survival Models and Data Analysis*. John Wiley.

Everitt BS & Dunn G. 1998. *Statistical Analysis of Medical Data*. Arnold.

Hosmer DW, Lemeshow S & May S. 2008. *Applied Survival Analysis: Regression Modeling of Time-to-Event Data*. 2nd Ed. John Wiley.

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

Kleinbaum DG & Klein M. 2002. *Logistic Regression*. Springer.

Kleinbaum DG & Klein M. 2005. *Survival Analysis. A Self Learning Text*. 2nd Ed. Springer.

Lee ET & Wang JW. 2003. *Statistical Methods for Survival Data Analysis*. John Wiley.

Therneau TM & Grambsch PM. 2000. *Modeling Survival Data: Extending the Cox Model*. Springer.

BST 670 ACTUARIAL STATISTICS 2+0

Objective

This course is meant to expose the students to the statistical techniques such as probability models, life tables, insurance and annuities, techniques in computation of premiums that include expenses, general expenses, types of expenses and per policy expenses.

Theory

UNIT I

Insurance and utility theory, models for individual claims and their sums, survival function, curtate

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

UNIT II

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

UNIT III

Distribution of aggregate claims, compound Poisson distribution and its applications. Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

UNIT IV

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

UNIT V

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

UNIT VI

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Net premium reserves, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions. Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

Suggested Readings

Atkinson ME & Dickson DCM. 2000. *An Introduction to Actuarial Studies*. Elgar Publ.

Bedford T & Cooke R. 2001. *Probabilistic Risk Analysis*. Cambridge.

Booth PM, Chadburn RG, Cooper DR, Haberman S & James DE. 1999. *Modern Actuarial Theory and Practice*. Chapman & Hall.

Borowiak Dale S. 2003. *Financial and Actuarial Statistics: An Introduction*. 2003. Marcel Dekker.

Bowers NL, Gerber HU, Hickman JC, Jones DA & Nesbitt CJ. 1997. *Actuarial Mathematics*. Society of Actuaries, Ithaca, Illinois.

Daykin CD, Pentikainen T & Pesonen M. 1994. *Practical Risk Theory for Actuaries*. Chapman & Hall.

Klugman SA, Panjer HH, Willmot and GE & Venter GG. 1998. *Loss Models: From data to Decisions*. John Wiley.

Medina PK & Merino S. 2003. *Mathematical Finance and Probability: A Discrete Introduction*. Basel, Birkhauser.

Rolski T, Schmidli H, Schmidt V & Teugels J. 1998. *Stochastic Processes for Insurance and Finance*. John Wiley.

Rotar VI. 2006. *Actuarial Models. The Mathematics of Insurance*. Chapman & Hall/CRC.

BST 671 STOCHASTIC PROCESSES 2+0

Objective

This is a course which aims at describing basic theory and applications of stochastic process. also helps prepare students for applications of this important subject to animal sciences.

Theory

UNIT I

Basics of stochastic processes. Random walk models. Markov chains and their applications. Discrete branching processes.

UNIT II

Markov processes in continuous time: Poisson process, Random-variable technique. Birth and death processes like pure birth process, linear birth and death process, immigration-birth-death process.

UNIT III

Epidemic processes: Simple deterministic and stochastic epidemic model. General epidemic models, Recurrent epidemics.

UNIT IV

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

Bartlett MS. 1955. *Introduction to Stochastic Processes.* Cambridge Univ. Press.
Bharucha-Reid AT. 1960. *Elements of the Theory of Markov Processes and their Applications.* McGraw Hill.
Bhat UN. 1972. *Elements of Applied Stochastic Processes.* Wiley Eastern.
Cox DR & Miller HD. 1965. *The Theory of Stochastic Processes.* Methuen.
Durrett R. 1999. *Essentials of Stochastic Processes.* Springer.
Lawler GF. 1995. *Introduction to Stochastic Processes.* Chapman & Hall.
Medhi J. 1982. *Stochastic Processes.* Wiley Eastern.
Parzen E. 1962. *Stochastic Processes.* Holden-Day.
Prabhu NU. 1965. *Stochastic Processes.* Macmillan.
Ross SM. 1996. *Stochastic Processes.* 2nd Ed. John Wiley.
Taylor HM & Karlin S. 1998. *An Introduction to Stochastic Modeling.* 3rd Ed. Academic Press.

BST 672 DEMOGRAPHIC TECHNIQUES IN BIO-STATISTICS 2+1

Objective

This course is meant for training the students in measures of demographic indices, estimation procedures of demographic parameters, 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; Application and methods of constructing life table, abridged life tables; Increment-Decrement Life Tables.

UNIT II

Stationary and stable populations, Stationary and stable populations, Migration and immigration. Demographic relations in Nonstable populations. Measurement of population growth, Lotka's model (deterministic) and intrinsic rate of growth, Measures of mortality and morbidity, Period and Cohort studies. Population projections

UNIT III

Fertility and reproduction: CBR, GFR, GRR and NRR. Measures of reproduction: total fertility rate, gross reproduction rate, net reproduction rate, replacement index, general fertility models.

UNIT IV

Estimation of median effective doses-their relative potency and standard errors.

UNIT V

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; Probit analysis, Confounding with natural mortality and methods of its adjustment, Odds-ratio, Mantel- Henszel

estimate and its confidence interval, testing of hypothesis in 2x2 and 2xk tables

Practical

Problems based on estimation of crude and standard mortality and morbidity rates. Construction of life tables; Estimation of CBR, GFR, GRR and NRR; Probit Analysis. Odds-ratio tests, Mantel-Henszel estimate and its confidence interval, testing of hypothesis in 2x2 and 2xk tables. Population projections.

Suggested Readings

Cox DR. 1957. *Demography.* Cambridge Univ. Press.
Everitt BS & Dunn G. 1998. *Statistical Analysis of Medical Data.* Arnold.
Fleiss JL. 1981. *Statistical Methods for Rates and Proportions.* John Wiley.
Lawless JF. 1982. *Statistical Models and Methods for Lifetime Data.* John Wiley.
MacMahon B & Pugh TF. 1970. *Epidemiology - Principles and Methods.* Little Brown.
Miettinen OS. 1985. *Theoretical Epidemiology: Principles of Occurrence Research in Medicine.* John Wiley.
Newell C. 1988. *Methods and Models in Demography.* Guilford Publ.
Preston S, Heuveline P & Guillot M. 2001. *Demography: Measuring and Modeling Population Processes.* Blackwell.
Rowland DT. 2004. *Demographic Methods and Concepts.* Oxford Press.
Siegel JS & Swanson DA. 2004. *The Methods and Material of Demography.* Elsevier.
Woolson FR. 1987. *Statistical Methods for the Analysis of Biomedical Data.* John Wiley.

BST 673 ECONOMETRICS AND OPERATIONAL RESEARCH 2+1

Objective

This course is meant for training the students in econometric methods, operations research 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 and estimation and testing of hypothesis in linear models not of full rank.

UNIT III

Generalized least squares method of estimation, Seemingly unrelated regressions.

UNIT IV

Heteroscedasticity, Auto - correlation, Distributed lag models. Elements of time-series analysis Components of time-series.

UNIT V

Measurement of secular trend-Methods of moving averages and curve fitting, Measurement o seasonal fluctuations, Measurement of cyclical fluctuations-Periodogram analysis, Harmoni analysis, Serial correlation and Correlogram.

Practical

Estimation of parameters of linear model through the methods of Ordinary Least Squares (OLS); Tes of significance of the estimates; Restricted Ordinary Least Squares Method, Generalized lea squares method, Weighted least squares method; Problem on Autocorrelation, Multicollinearit Dummy variation, Heteroscedasticity; Analysis of timeseries data. Serial correlation an Correlogram.

Suggested Readings

Anderson TW. 1971. The Statistical Analysis of Time Series. John Wiley.
Baltagi BH. 1999. Econometrics. Springer.
Belsley DA, Kuh E & Welsch RE. 1980. Regression Diagnostics: Identifying Influential Data and Source of Collinearity. John Wiley.
Everitt BS. 1987. Introduction to Optimization Methods and their Application in Statistics. Chapman & Hall.
Johnston J. 1984. Econometric Methods. McGraw Hill.
Klein LR. 1975. A Text Book of Econometrics. Prentice Hall of India.
Koutsoyiannis A. 1992. Theory of Econometrics. Macmillan.
Maddala GS. 1977. Econometrics. McGraw Hill.
Rao SS. 1984. Optimization Theory and Application. Wiley Eastern.
Rustagi JS. 1994. Optimization Techniques in Statistics. Boston Academic Press.
Taha HA. 1999. Operations Research: An Introduction. Prentice Hall of India.
Theil H. 1971. Principles of Econometrics. John Wiley.
Zeleny M. 1974. Linear Multi-objective Programming - Lecture Notes in Economics and Mathematical Systems. Sr.95. Springer.

BST 674 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, by exposing to methods of optimization, linear programming techniques, non-linear programming and multiple objective programming.

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

based on Pontryagin's Maximum Principle.

Suggested Readings

Rao SS. 2007. *Engineering Optimization: Theory and Practice.* 3rd Ed. New Age.
Rustagi JS. 1994. *Optimization Techniques in Statistics.* Academic Press.
Taha HA. 2007. *Operations Research: Introduction with CD.* 8th Ed. Pearson Edu.
Zeleny M. 1974. *Linear Multiobjective Programming.* Springer.

MCA 601 COMPUTER FUNDAMENTALS AND PROGRAMMING 2+1

Objective

This course builds an understanding of the structure of computers and how they execute programs, data representation and computer arithmetic. The course is also aimed to develop problem-solving strategies, techniques and skills to help students develop the logic, ability to solve the problems efficiently using C programming.

Theory

UNIT I

Computer Fundamentals - Number systems: decimal, octal, binary and hexadecimal; Representation of integers, fixed and floating point numbers, character representation; ASCII, EBCDIC.

UNIT II

Functional units of computer, I/O devices, primary and secondary memories.

UNIT III

Programming Fundamentals with C - Algorithm, techniques of problem solving, flowcharting, stepwise refinement; Representation of integer, character, real, data types; Constants and variables; Arithmetic expressions, assignment statement, logical expression.

UNIT IV

Sequencing, alteration and iteration; Arrays, string processing.

UNIT V

Sub-programs, recursion, pointers and files.

UNIT VI

Program correctness; Debugging and testing of programs.

Practical

Conversion of different number types; Creation of flow chart, conversion of algorithm/flowchart to program; Mathematical operators, operator precedence; Sequence, control and iteration; Arrays and string processing; Pointers and File processing.

Suggested Readings

Balaguruswamy E. 1998. Programming with ANSI C. Tata McGraw Hill.
Gottfried B. 1999. Programming with C, Schaum Outline Series. Tata McGraw Hill.
Kanetkar Y. 1999. Let Us C. BPB Publ.
Malvino AP & Brown JA. 1999. Digital Computer Electronics. Tata McGraw Hill.
Mano MM. 1999. Digital Logic and Computer Design. Prentice Hall of India.

MCA 602 INTRODUCTION TO NETWORKING AND INTERNET APPLICATIONS 1+1

Objective

The course is aimed to provide fundamentals of networking and application protocols with the emphasis on developing web based applications.

Theory

UNIT I

Networking fundamentals, types of networking, network topology; Introduction to File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP).

UNIT II

World Wide Web (WWW), working with Internet; Web pages, web sites, web servers; Web Applications.

UNIT III

Hyper Text Markup Language (HTML), DHTML, web based application development.

Practical

Network and mail configuration; Using Network Services; Browsing of Internet; Creation of web pages; Creation of websites using HTML and Creation of websites using DHTML.

Suggested Readings

Buyens J. 2002. Microsoft FrontPage -Inside Out. Microsoft Press.
Cox V, Wermers L & Reding EE. 2006. HTML Illustrated Complete. 3rd Ed. Course Technology.
Niederst J. 2001. Web Design in a Nutshell. O'Reilly Media.
Tanenbaum AS. 2003. Computer Networks. Prentice Hall of India.

MCA 652 NUMERICAL ANALYSIS 2+0

Objective

The primary objective of the course is to develop the basic understanding of the construction of numerical algorithms, and perhaps more importantly, the applicability and limits of their appropriate use.

Theory

UNIT I

Introduction to complex variables; Basic concepts: Floating point number system, Implication of finite precision, Rounding off errors.

UNIT II

Interpolation: Polynomial interpolation, Inverse interpolation, Spline interpolation; Numerical integration: Trapezoidal rule, Simpson's 1/3rd and 3/8th rules; Ordinary differential equations: Runge-Kutta methods, Predictor - corrector methods.

UNIT III

Linear system of equations: Gaussian's elimination, Operation counts, Implementation including pivoting and scaling, Direct factorization methods, Iterative techniques and their analysis.

UNIT IV

Linear Difference equations; Non-linear equations : Bisection, Newton Raphson, false positions, Secant methods, Iterative methods.

UNIT V

Inverse of Matrices; Computation of eigen values and eigen vectors: Error estimates, the power methods – Jaccobi and Householder Method.

UNIT VI

Exposure to mathematical software packages.

Suggested Readings

Atkinson KE & Han W. 2003. Elementary Numerical Analysis. 3rd Ed. John Wiley.
Atkinson KE. 1978. An Introduction to Numerical Analysis. John Wiley.
Jain MK, Iyengar SRK & Jain RK. 2007. Numerical Methods for Scientific and Engineering Computation. 7th
Ed. New Age.
Kennedy WJ & Gentle JE. 1980. Statistical Computing. Marcel Dekker.
Krishnamurthi EV & Sen SK. 1986. Computer – Based Numerical Algorithms. East West Publ.
Yakowitz S & Szidarovszky F. 1986. An Introduction to Numerical Computation. MacMillan.

AHS 602 COMPUTER APPLICATIONS IN ANIMAL SCIENCES 1+1

Objective

To expose to the computer concepts and computer applications in animal

sciences.

Theory

UNIT - I

Evolution of computers, Classification, Generations, Benefits and limitations, Applications, Physical components (Hardware). Software, Files and directories, File naming, Operating system, DOS, Windows – Advantages, Desktop, Parts and applications in Windows, Windows Explorer

UNIT – II

Word Processing - Features, Opening, Formatting, Editing, Tables, Saving, Printing. Spreadsheet operations - Worksheet, Rows and columns, Labels, Number, Formula, Functions (Mathematical / Statistical), Printing, Graphs and charts. Presentation software - Starting and choosing design, Layout, Formatting, Tables, Chart, Graphics and images, Slide show, slide transitions, customizing

UNIT – III

Introduction to Computer network, LAN and WAN. Basics of GIS, Internet and Email. Computer applications in animal sciences

Practical

DOS commands, Windows applications, Word processing, Spread sheet operations, Presentation software, Internet and E-Mail Applications

Suggested Readings

Arick MR. 1994. *The TCP/IP Companion - A Guide for Common User*. Shroff Publ.

Burrough PA. 1986. *Principles of Geographic Information System for Land Resources Assessment*. Oxford Univ. Press.

Deitel HM. 1990. *An Introduction to Operating System*. Addison Wesley.

Hayes JP. 1988. *Computer Architecture and Organisation*. McGraw Hill.

Mano MM. 2007. *Computer System Architecture*. Prentice Hall of India.

Tanenbaum AS. 2000. *Modern Operating Systems*. Prentice Hall of India.

Tanenbaum AS. 2003. *Computer Networks*. Prentice Hall of India.

BST 651 BASIC MATHEMATICS – I 3+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

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

UNIT II

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

UNIT III

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

UNIT IV

C Section

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

Suggested Readings

Bartle RG. 1976. *Elements of Real Analysis*. John Wiley.
Chatterjee SK. 1970. *Mathematical Analysis*. Oxford & IBH.
Gibson GA. 1954. *Advanced Calculus*. Macmillan.
Henrice P. 1964. *Elements of Numerical Analysis*. John Wiley.
Hildebrand FB. 1956. *Introduction to Numerical Analysis*. Tata McGraw Hill.
Priestley HA. 1985. *Complex Analysis*. Clarenton Press.
Rudin W. 1985. *Principles of Mathematical Analysis*. McGraw Hill.
Sauer T. 2006. *Numerical Analysis With CD-Rom*. Addison Wesley.
Scarborough JB. 1976. *Numerical Mathematical Analysis*. Oxford & IBH.
Stewart J. 2007. *Calculus*. Thompson.
Thomas GB Jr. & Finney RL. 1996. Calculus. 9th Ed. Pearson Edu.

BST 652 BASIC MATHEMATICS – II 2+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. Graph theory: Concepts and applications

UNIT II

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

UNIT III

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

UNIT IV

Generalized inverses, Moore-Penrose inverse, Applications of g-inverse. Spectral decomposition of matrices, Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of matrices, Quadratic forms.

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.
Gentle J E. 2007. *Matrix Algebra: Theory, Computations and Applications in Statistics*. Springer.
Graybill FE.1961. *Introduction to Matrices with Applications in Statistics*. Wadsworth Publ.
Hadley G. 1969. *Linear Algebra*. Addison Wesley.
Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.
Rao CR. 1965. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.
Robinson DJS. 1991. *A Course in Linear Algebra with Applications*. World Scientific.
Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.
Seber GAF. 2008. *A Matrix Handbook for Statisticians*. John Wiley.

Compulsory Non-Credit Courses

The following non-credit courses are compulsory for the students of MVSc in Bio-Statistics.

CODE	COURSE TITLE	CREDITS
PGS 601	Library and information services	0+1
PGS 602	Technical writing and communications skills	0+1
PGS 603 (e-Course)	Intellectual property and its management in agriculture	1+0
PGS 604	Basic concepts in laboratory techniques	0+1
PGS 605 (e-Course)	Agricultural research, research ethics and rural development programmes	2+1
PGS 606 (e-Course)	Disaster management	1+0
PGS 607	Livestock and poultry production – concepts and practices	2+1

PGS 607 is compulsory for the non-veterinary graduates, while PGS 604 is not needed as it is less relevant for the students of Bio-Statistics. The syllabus for the courses PGS 601, PGS 602, PGS 603, PGS 605 and PGS 606 are as per the ones stipulated in the TANUVAS PG Regulations 2009, while that for PGS 607 is as below (which was circulated among the HoDs of the Depts. of LPM and PSc of MVC who certified for the appropriateness of the contents for the course to be offered in the programme):

PGS 607 LIVESTOCK AND POULTRY PRODUCTION: CONCEPTS AND PRACTICES 2+1

Objective

To impart theoretical and practical knowledge about livestock and poultry production.

Theory

UNIT I

Important breeds of cattle, buffalo, sheep, goats, pigs and poultry in India, Methods of identification of animals, Selection of animals for production and breeding, Breeding seasons, natural breeding, artificial breeding

UNIT II

Breeding management - Methods of breeding, Pre and Postnatal care and management, Feeding management – Feeding methods, computation of economical ration, green and dry fodder feeding; water requirement

UNIT III

Housing requirements and systems for different species of livestock and poultry, General layout of farm houses, fittings, facilities, Sanitation and hygiene.

UNIT IV

Management of special category of animals – young ones, heifers, pregnant, lactating, dry, ailing, etc. UNIT V

Management of chicks, growers, layers and breeders, Poultry housing - Cages vs. Floor system, Litter management and lighting, Feeding management, selection and culling of laying flocks. Vaccination and deworming. Hatchery management, methods of incubation.

Practical

Visits to livestock and poultry farms, Study of breeding management, Study of feeding management, Record keeping, Disease management - vaccination and deworming, Marketing of livestock, poultry and their products.

List of Journals

• American Statistician	• Annals of Institute of Statistical Mathematics
• Annals of Statistics	• Australian and New Zealand Journal of Statistics
• Biometrical Journal	• Biometrics
• Biometrika	• Bulletin of Calcutta Statistical Association
• Canadian Journal of Statistics	• Experimental Agriculture
• Communication in Statistics (Theory & and Methods)	• Communication in Statistics (Simulation & Computation)
• Institute of Mathematical Statistics Bulletin (IMSB)	• Journal of the Indian Society of Agrl. Statistics
• Journal of Applied Statistics	• Journal of American Statistical Association
• Journal of the International Statistical Review	• Journal of Statistical Planning and Inference
• Journal of Statistical Theory and Practice	• Journal of Statistics, Computer and Applications
• Journal of Royal Statistical Society, Series A	• Journal of Royal Statistical Society, Series B
• Journal of Royal Statistical Society, Series C	• Metrika
• Metron	• Scandinavian Journal of Statistics (Theory & Applied)
• Sankhya	• Statistica
• Statistical Science	• Statistics and Probability Letters
• Technometrics	

e-Resources

- *IASRI (ICAR), New Delhi 110 012, India.* www.iasri.res.in/design.
- Design Resources: www.designtheory.org
- Free Encyclopedia on Design of Experiments
- http://en.wikipedia.org/wiki/Design_of_experiments
- Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
- Electronic Statistics Text Book: http://www.statsoft.com/textbook/stathome.html.
- Hadamard Matrices http://www.research.att.com/~njas/hadamard.
- Hadamard Matrices http://www.uow.edu.au/~jennie/WILLIAMSON/williamson.html.
- Course on Experimental design: http://www.stat.sc.edu/~grego/courses/stat706/.
- Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
- Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
- Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
- Statistical Calculators: http://www.graphpad.com/quickcalcs/index.cfm
- SAS Online Doc 9.1.3 : http://support.sas.com/onlinedoc/913/docMainpage.jsp

Suggested Broad Topics for Research

- Design and analysis of experiments
- Bayesian designing of experiments, optimality and analysis of experimental data
- Computer aided search of efficient experimental designs for various experimental settings
- Fractional factorials including search designs, supersaturated designs, computer experiments, etc.
- Statistical techniques in bioinformatics, biotechnology, microbiology, genomics, etc.
- Optimality aspects and robustness of designs against several disturbances under various experimental settings (single factor, multi-factor, nested classifications, etc.)
- Small area estimation

- Computer intensive techniques in sample surveys
- Analysis of survey data, regression analysis, categorical data analysis, analysis of complex survey data
- Assessment and impact survey methodologies, valuation of natural resources, its degradation, depletion
- Linear and non-linear modeling of biological and economical phenomena
- Non-linear time series modeling
- Non-linear stochastic modeling
- Forecast models for both temporal and spatial data
- Innovative applications of resampling techniques
- Applications of remote sensing, GIS, ANN etc. in modeling various phenomena
- Econometric models for risk, uncertainty, insurance, market analysis, technical efficiency, policy planning, etc.
- Statistical studies on value addition