Sher-e-Kashmir
University of Agricultural Sciences and Technology of Jammu

Division of Statistics & Computer Science

BROCHURE

I. **Name of the Division:** Division of Statistics & Computer Science

II. Faculty Profile:

	Name :	Dr. Manish Kumar Sharma
	Designation :	Professor & Head
	Area of Specialization :	Sampling Theory, Statistical Modelling and Statistical softwares
	E mail :	manshstat@gmail.com
	Contact No :	94191-98062

	Name :	Dr. S.E.H. Rizvi
	Designation :	Professor
	Area of Specialization :	Sampling Theory (Optimum Stratification), Applied Statistics, Statistical Modelling
	E mail :	sehrizvi_stats@yahoo.co.in
	Contact No :	094191-38953

	Name :	Dr. Sunali Mahajan
	Designation :	Assistant Professor(Contractual)
	Area of Specialization :	Statistical Modelling, Applied Statistics
	E mail :	sunali12mahajan@gmail.com
	Contact No :	9796827726

Name :	Dr. Akshita Sharma
Designation :	Assistant Professor(Contractual)
Area of Specialization :	Reliability Theory
E mail :	akshita.sharma93@gmail.com
Contact No :	9906032376

III. Available Infrastructure and establishments: (Smart Class Room and SDAC)

The Smart Classroom and Statistical Data Analysis Cell (SDAC) inaugurated by Sh. Atal Dulloo, IAS, Financial Commissioner (Additional Chief Secretary), Agriculture Production & Farmers Welfare Department, J&K on 21st October, 2022 in presence of Prof. J.P. Sharma, Vice-Chancellor, SKUAST-J and Prof. Nazir Ahmed Ganai, Vice-Chancellor, SKUAST-K.

IV. Academic/Research/Extension Achievements:

i. ACADEMIC ACTIVITIES:

PASSEDOUT STUDENTS	**M.Sc.** **Ph.D**	**13** **08**
PURSUING STUDENTS	**M.Sc.** **Ph.D**	**06** **05**

ii. EXTENSION ACTIVITIES:

SR.NO.	CONTENT	NOS.
1.	TRAINING/WORKSHOP ORGANIZED	06
2.	INVITED LECTURES	150
3.	LIST OF BOOK CHAPTERS PUBLISHED	15
4.	MAUALS/COMPENDIUM	09
5.	PARTICIPATIONS/WORKSHOPS	70
6.	PARTICIPATION IN REFERESHER/PROFESSIONAL	15

	COURSES/SUMMER/WINTER SCHOOLS	

V. Major Events/Activities organized including conferences/Seminars/Workshops etc.

i. 19th Annual National Conference of SSCA: 19th Annual National conference of the Society of Statistics, Computer and Applications (SSCA), has been organized by Division of Statistics and Computer Science, Faculty of Basic Sciences at Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Chatha w.e.f March 06-08, 2017.

ii. Workshop on Statistical Learning & Analysis for Researchers

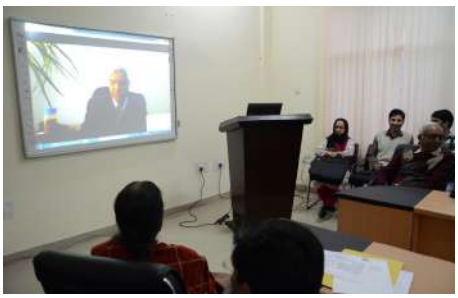
iii. National Statistics Day (June, 29) in the Division

iv. Training on Applications of Computers and IT Tools in Improving Learning and Research Efficacy of Students

v. Training on Big Data Analysis on Research Methods Using Statistical Softwares w.e.f. 26-07-2022 to 01.08.2022.

VI. Visit of Important Dignitaries:

PROF. R.B. BARMAN, CHAIRMAN NATIONAL STATISTICAL COMMISSION



DR. MURARI SINGH, ICARDA, LEBANON

PROF. G.C. MANNA, DIRECTOR GENERAL OF CSO & NSSO

PROF. SAT GUPTA, UNIVERSITY OF NORTH CAROLINA, GREENSBORO

PROF. RAJENDER PARSAD, DIRECTOR, IASRI

DR. SEEMA JAGGI, ADG, ICAR interacted with faculty and student

Lecture by Former National Professor V. K. Gupta

COURSE CURRICULUM

MASTER OF SCIENCE

IN

AGRICULTURE

(AGRIL. STATISTICS)

DIVISION OF STATISTICS & COMPUTER SCIENCE

FACULTY OF BASIC SCIENCES

Degree Programme:

M.Sc. Agriculture (Agril. Statistics)

Programme at a Glance

Minimum Credit requirements:

Particulars	**Credit Hrs.**
Major	20
Minor	08
Supporting	06
Seminar	01
Research	30
Total Credits	**65**
Compulsory non-Credit Courses	**05**

Major:

Core Courses:

Course No.	**Course title**	**Credit Hrs.**	**Sem.**
STAT552	PROBABILITY THEORY	2+0	I
STAT553	STATISTICAL METHODS	2+1	I
STAT562	STATISTICAL INFERENCE	2+1	II
STAT563	DESIGN OF EXPERIMENT	2+1	II
STAT564	SAMPLING TECHNIQUES	2+1	II

Optional Courses:

Course No.	**Course title**	**Credit Hrs.**	**Sem.**
STAT 554	ACTUARIAL STATISTICS	2+0	I
STAT 555	BIOINFORMATICS	2+0	I
STAT 556	ECONOMETRICS	2+0	I
STAT 565	STATISTICAL GENETICS	2+1	II
STAT 566	STATISTICAL QUALITY CONTROL	2+0	II
STAT 567	OPTIMIZATION TECHNIQUES	1+1	II
STAT 571	MULTIVARIATE ANALYSIS	2+1	III
STAT 572	REGRESSION ANALYSIS	1+1	III
STAT 573	STATISTICAL COMPUTING	1+1	III
STAT 574	TIMESERIES ANALYSIS	1+1	III

STAT 575	DEMOGRAPHY	2+0	III
STAT 576	STATISTICAL METHODSFOR LIFE SCIENCES	2+0	III
STAT 577	STATISTICAL ECOLOGY	2+0	III
Seminar:			
STAT 591	SEMINAR	1+0	I/II
Research:			
STAT 599	RESEARCH	0+30	I-IV

Minor:

The student's advisory committee will decide about the minor course(s) from the other disciplines as required

Supporting Courses (Mathematics):

Course No.	Course title	Credit Hrs.	Sem.
STAT 551	MATHEMATICS-I	3+0	I
STAT 561	MATHEMATICS-II	2+0	II

STAT 552 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 basics 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: classofsets, field, sigmafield, 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 the irrelation, 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. Chebyshev, Markov, Cauchy-Schwartz, Sequence of random variables and modes of convergence (convergence in distribution in probability, almostsurely, and quadratic mean) and the interrelations.

UNIT IV

Laws of large numbers: WLLN, Bernoulli and Kintchin's WLLN. Kolmogorov in equality, Kolmogorov's SLLNs. Central Limit theorems: Demoviere-Laplace CLT, Lindberg – Levy CLT and simple applications.

Suggested Readings

Ash RB.2000. *Probabilit yand 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 C., Tomasz J.Z. (2003). *Probability* Through Problems (Problem Books in Mathematics) Corrected Ed.

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

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

Statistics. 2nd Ed. John Wiley.

STAT553 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). 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 andregression.

UNIT IV

Sampling distribution of correlation coefficient, regression coefficient. Categorical data analysis, Association between attributes. Variance StabilizingTransformations.

UNIT V

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

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. 2012. *Categorical Data Analysis* 3rd Ed. John Wiley.

ArnoldBC,BalakrishnanN&Nagaraja HN.1992. *A First Course in Order Statistics*. JohnWiley.

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*. JohnWiley.

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

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

RaoCR.1965. *Linear Statistical Inference and its Applications*. John Wiley.

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

Gupta. S.P 2008. Statistical Methods. Sultan Chand & sons *Educational*

Publisher

STAT562 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: 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 theirproperties.Interval estimation-Confidence level, shortest length CI. CI for the parameters of Normal, Exponential, Binomial and Poisson distributions.

UNIT III

Fundamentals 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, asymptotic properties of LR tests with applications (including homogeneity of means and variances).Relation between confidence interval estimation and testing of hypothesis.

UNIT IV

Sequential Probability ratio test, Properties of SPRT.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. 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*. JohnWiley.

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

Kiefer JC. 1987. *Introduction to Statistical Inference*. Springer. Lehmann EL. 1986. *Testing Statistical Hypotheses*. John Wiley. Lehmann EL. 1986. *Theory of Point Estimation*. John Wiley.

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

Rao CR. 2009. *Linear Statistical Inference and its applications*, 3rdEd.

John Wiley.

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

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

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

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

Michael J.Panik. 2012. Statistical Inference. A John Wiley &*sons*, INC, publication

STAT563 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 andblocks, Randomization procedure.

UNIT III

Basic designs - completely randomized design, randomized complete block design and Latin square design; Construction of 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.

UNITV

Factorial experiments, confounding in symmetrical factorial experiments ($2^n$and 3^nseries), partial and total confounding, asymmetricalfactorials.

UNIT VI

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; 2^n, 3^n factorial experiments without and with confounding; Split and strip plot designs, repeated measurement design; Missing plot techniques, Analysis of covariance; Analysis of Groups of experiments, Analysis of clinical trial experiments.

Suggested Readings

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

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.

DeyA 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. 2013. *Design and Analysis of Experiments*. *JohnWiley&*

Sons

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

Searle SR. 2006. *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.drs.icar.gov.in.

STAT564 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 ofparameters.

Theory

UNIT I

Sample survey vs complete enumeration, probability sampling, sample space, sampling design, sampling strategy; Determination of sample size; Confidence-interval; Simple random sampling, Estimation of population proportion, Stratified random sampling, Proportional allocation and optimal allocation, Inverse sampling.

UNIT II

Ratio, Product 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. Unbiased ratio type estimators

UNIT III

Non-sampling errors – sources and classification, Non-response in surveys, Randomized response techniques, Response errors/Measurement error – interpenetrating sub-sampling.

UNIT IV

PPS Sampling with and without replacement, Cumulative method and Lahiri's method of selection, Horvitz-Thompson estimator, Ordered and unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran. Inclusion probability proportional to size sampling.

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 varyingprobabilities.

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.

Mukhopadhyay , P.2008.*Theory and Methods of Survey Sampling*, John Wiley & Sons

Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. StatisticalPubl.

Society, Calcutta.

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.

William. G. Kochran.2007. Sampling Techniques. A John Wiley & Sons

Publication

STAT 554 ACTUARIAL STATISTICS 2+0

Objective

This course is meant to expose to the students to the statistical techniques such as probability models, life tables, insurance and

annuities. The students would also be exposed top practical applications of these 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.

UNIT II

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

UNIT III

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

UNIT IV

Distribution of aggregate claims, compound Poisson distribution and its applications.

UNIT V

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

UNIT VI

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

UNIT VII

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

UNIT VIII

Net premiums: Continuous and discrete premiums, true monthly

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

UNIT IX

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

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. 2nd Ed. Society of Actuaries, Ithaca,

Illinois.

Dale SB, Arnold FS 2013. *Financial and Actuarial Statistics: An Introduction*, 2nd Ed. (Statistics: A Series of Textbooks and Monogrphs)

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

Klugman SA, Panjer HH, Willmotand 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.

Melnikov, A. 2011. Risk Analysis in Finance *and* Insurance (Chapman & Hall/Crc Financial Mathematics Series) 2nd Ed.

Neill A. 1977. *Life Contingencies*. Butterworth-Heinemann.

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.

Spurgeon ET. 1972. *Life Contingencies*. Cambridge Univ. Press.

STAT 555 BIOINFORMATICS 2+0

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

UNIT II

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

UNIT III

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques –

Bootstrapping and Jack-knifing; Hidden Markov Models; Bayesian estimation and Gibbs sampling;

UNIT IV

Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis, Approaches to EST analysis; 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, Multiple alignment and database search using motif models, ClustalW, Phylogeny; Databases on SNPs; EM algorithm and other methods to discover common motifs in biosequences; Gene prediction based on Neural Networks, Genetic algorithms, Computational analysis of protein sequence, structure and function; Design and Analysis of microarray/RNAseqexperiments.

Suggested Readings

Baldi P &Brunak S. 2001. *Bioinformatics: The Machine Learning Approach.* 2nd Ed. (Adaptive Computation and Machine Learning). MIT Press.

Baxevanis AD & Francis BF. (Eds.). 2004. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. John Wiley.

Bergeron BP. 2002. *Bioinformatics Computing*. Prentice Hall.

Duda RO, Hart PE & Stork DG. 1999. *Pattern Classification*. John Wiley. Ewens WJ & Grant GR. 2001. *Statistical Methods in Bioinformatics: An Introduction* (*Statistics for Biology and Health*). Springer.

Graham B.Zweig, J. Buffett, WE. 2006.*The Intelligent Investor: The Definitive Book on Value Investing.* A Book of Practical Counsel, Revised Edition

Hunt S & Livesy F. (Eds.). 2000. *Functional Genomics: A Practical Approach* (*The Practical Approach Series, 235*). Oxford Univ. Press.

Jones NC &Pevzner PA. 2004. *An Introduction to Bioinformatics Algorithims*. MIT Press.

Koski T & Koskinen T. 2001. *Hidden Markov Models for Bioinformatics*.Kluwer.

Krane DE & Raymer ML. 2002. *Fundamental Concepts of Bio-informatics*.

Benjamin / Cummings.

Krawetz SA &Womble DD. 2003. *Introduction to Bioinformatics: A Theoretical and Practical Approach*. Humana Press.

Lesk AM. 2002. *Introduction to Bio-informatics*. Oxford Univ. Press.
Percus JK. 2001. *Mathematics of Genome Analysis*. Cambridge Univ. Press.

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

Tisdall JD. 2001. *Mastering Perl for Bioinformatics*. O'Reilly &Associates.

Tisdall JD. 2001. B*eginning Perl for Bioinformatics*. O'Reilly & Associates.

Wang JTL, Zaki MJ, Toivonen HTT & Shasha D. 2004. *Data Mining in Bioinformatics*. Springer.

Wu CH &McLarty JW. 2000. *Neural Networks and Genome Informatics*.

Elsevier.

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

STAT 556 ECONOMETRICS 2+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNITIV

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

UNIT V

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

Suggested Readings

Croxton FE & Cowden DJ. 1979. *Applied General Statistics*. Prentice Hall of India.

James HS & Mark WW. 2017. Introduction to Econometrics, 3rd Ed. John Wiley

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

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

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

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

Maddala GS. 2001. *Introduction to Econometrics*. 3rd Ed. John Wiley.

Pindyck RS & Rubinfeld DL. 1998. *Econometric Models and Economic Forecasts*. 4th Ed. McGraw Hill.

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

STAT565 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 selectionindices.

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 pathcoefficients.

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 populationsize.

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, Multipleallelism 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.

UNITVI

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 toselection.

Suggested Readings

Agarwal. B.L, Agarwal. S.P 2007. *Statistical Analysis of Quantitative Genetics.* New Age International Publisher.

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.

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& JinksJL.1977.*IntroductiontoBiometricalGenetics*.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. N. P. 1990. *Statistical Genetics*. Wiley Eastern.

STAT 566 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 DJ. 1957. *Statistical Methods in Quality Control*. Prentice Hall of India.

Dodge HF &Romig HG. 1959. *Sampling Inspection Tables*. John Wiley. Duncan A.J. 1986. *Quality Control and Industrial Statistics*. 5th Ed. Irwin Book Co.

Grant EL & Leavenworth RS. 1996. *Statistical Quality Control*. 7th Ed.

McGraw Hill.

Montgomery DC. 2008. *Introduction to Statistical Quality Control*. 6th Ed.

John Wiley.

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

STAT567 OPTIMIZATION TECHNIQUES 1+1

Objective

This course is meant for exposing the students to the mathematical details of the techniques optimization techniques. 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

Classification of optimization problems, Classical optimization

techniques: single variable optimization, multivariable optimization techniques with no constraints, multivariable optimization techniques with equality constraints, multivariable optimization techniques with inequality constraints.

UNIT II

Linear programming: simplex method, duality, sensitivity analysis, Karmarkar's method, transportation problem.

UNIT III

Nonlinear programming Unconstrained optimization techniques: direct search methods such as random search, grid search, Hooke and Jeeves' method, Powel's method. Descent methods such as gradient method, steepest descent method, conjugate gradient method, Newton's method, Marquardt method.

UNIT IV

Quadratic programming, integer linear programming, integer nonlinear programming, geometric programming, dynamic programming, stochastic programming, multiobjective optimization, optimal control theory, genetic algorithms, simulated annealing, neural network based optimization,

Practical

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

SuggestedReadings

Antunes CH, Alves, MJ, Climaco J. 2016. *Multi objective Linear and Integer Programming* (EURO Advanced Tutorials on Operational Research)

Nocedal, J. and Wright, S. J. 1999. *Numerical Optimization*. Springer. Rao, S.S. 2007. *Engineering Optimization: Theory and Practice*. New

Age International Publishers.

Rustagi, J.S. 1994. *Optimization Techniques in Statistics*. Academic Press. Taha, H.A. 2007. *Operations Research: Introduction with CD*. Pearson

Education.

Xu, H, Teo , KL Zhang Y. 2016. *Optimization and Control Techniques and Applications* (Springer Proceedings in Mathematics & Statistics)

Zeleny, M. 1974. *Linear Multi objective Programming*. Springer.

STAT 571 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 its properties. Concepts of discriminant analysis, computation of linear discriminant function, classification between k (≥ 2) multivariate normal populations based on LDF and MahalanobisD^2.

UNIT III

Principal Component Analysis, factor analysis. Canonical variables and canonical correlations. Cluster analysis: similarities and dissimilarities of qualitative and quantitative characteristics, Hierarchical clustering. Single, Complete and Average linkage methods. K-means cluster analysis.

UNIT IV

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

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

Abdelmonem A, Virginia AC and Susanne M. 2004. *Computer Aided Multivariate Analysis*. Chapman & Hall/CRC.

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. Muirhead, RJ. (2005) *Aspects of Multivariate Statistical Theory*. 2nd Ed. John Wiley.

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

Rencher AC. 2012. *Methods of Multivariate Analysis*. 3rd Ed. John Wiley.

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

STAT572 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.

UNIT II

Assumptions of regression; diagnostics and transformations; residual analysis ~ Studentized residuals, applications of residuals in detecting outliers, identification of influential observations. Lack of fit, Pure error. Test of normality, test of linearity,Testing homoscedasticity and normality of errors, Durbin-Watson test. Test of goodness of fit for the model evaluation and validation.Concept of multi-collinearity

UNIT III

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

UNIT IV

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 polynomialfitting.

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 AS. 2013. *Regression Analysis by Example*. A John Wiley & sons Publication.

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

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

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

Rao CR. 1973. *Linear Statistical Inference and its Applications*.

2nd*Ed*.John Wiley.

STAT573 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, Use of Software packages like, SAS, SPSS or "R: The R Project for Statistical Computing". Data analysis principles and practice, Summarization and tabulation of data, Exploratory data analysis; Graphical representation of data.Statistical Distributions:Fitting and testing the goodness of fit of discrete and continuous probability distributions;

UNIT II

ANOVA, regression and categorical data methods; model formulation, fitting, diagnostics and validation; Matrix computations in linear models. Analysis of discrete data. Multiple comparisons, Contrast analysis

UNIT III

Numerical linear algebra, numerical optimization, graphical techniques, numerical approximations, Time Series Analysis

UNIT IV

Analysis of mixed models; Estimation of variance components, Analysis of Covariance, Fitting of non-linear model, Discriminant function; Principal component analysis. 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;Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test for large samples - Chi-squares test, F test, One way analysis of variance, contrast and its testing, pairwise comparisons;mixed effect models, estimation of variance components; Categorical data analysis, dissimilarity measures, similarity measures;analysis of discrete data, analysis of binary data; Numerical algorithms; Spatial modeling, cohort studies; Clinical trials, analysis of survival data; Handling missing data.Analysis of time series data - fitting of ARIMA models,

SuggestedReadings

Agresti A. 2013. *Categorical Data Analysis*. 3rd 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. 2012. *Handbook of Computational Statistics - Concepts and Methods.* 2nd Ed. 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.

Singh, Akhilesh Kumar. 2016. *Practical R-Book by Examples for Agricultural Statistics.* Deptt. Of Ag. Statistics, IGKV. Raipur

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.
http://www.r-project.org/

http://www.stat.sc.edu/~grego/courses/stat706/
. Design Resources Server:
www.drs.icar.gov.in.

STAT574 TIME SERIES ANALYSIS 1+1

Objective

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

Theory

UNIT I

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

UNIT II

Linear stationary models: Autoregressive, moving average and Mixed processes. Linear non-stationary models: Autoregressive integrated moving average processes.

UNIT III

Forecasting: Minimum mean square forecasts and their properties, Calculating and updating forecasts.

UNIT IV

Model identification: Objectives, Techniques, and Initial estimates. Model estimation: Likelihood function, Sum of squares function, Least squares estimates. Seasonal models. Intervention analysis models and Outlier detection.

Practical

Time series analysis, autocorrelations, correlogram and periodogram; Linear stationary model; Linear non-stationary model; Model identification and model estimation; Intervention analysis and outlier detection.

Suggested Readings

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

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

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

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

Jenkins, GM, Reinsel, GC, Greta M. L,George E. P. B (2015).*Time Series Analysis: Forecasting and Control*, Wiley Series in Probability and Statistics

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

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

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

Montgomery DC Jennings CA. Kulahci M. 2015. Introduction to Time Series Analysis and Forecasting, Wiley Series in Probability and Statistics

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

STAT575 DEMOGRAPHY 2+0

Objective

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

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'smodel(deterministic) and intrinsic rate of growth, Measures of mortality and morbidityPeriod.

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 DR. 1957. *Demography*. Cambridge Univ. Press.

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

Finney DJ. 1981. *Statistical Methods in Biological Assays*.

Grow A, Bavel JV. 2016. *Agent-Based Modelling in Population Studies: Concepts, Methods, and Applications* (The Springer Series on Demographic Methods and Population Analysis)

Lawless JF. 1982. *Statistical Models and Methods for Lifetime Data*. John Wiley.

MacMahon B & Pugh TF. 1970. *Epidemiology- Principles and Methods*.Little Brown, Boston.

Mann NR, Schafer RE &Singpurwalla ND. 1974. *Methods for Statistical Analysis of Reliability and Life Data*. John Wiley.

Newell C. 1988. *Methods and Models in Demography*. Guilford Publ. Preston S, Heuveline P &Guillot M. 2001. *Demography: Measuring andModeling Population Processes*. Blackwell Publ.

Rowland DT. 2004. *Demographic Methods and Concepts*. Oxford Press.

Siegel JS & Swanson DA. 2004. *The Methods and Material ofDemography*. 2nd Ed. Elsevier.

Woolson FR. 1987. *Statistical Methods for the Analysis of Biomedical Data*. JohnWiley.

Yakovlev AY, Klebanov L, Gaile D. 2013. *Statistical Methods for Microarray Data Analysis: Methods and Protocols* (Methods in Molecular Biology)

STAT576 STATISTICAL METHODS FOR LIFE SCIENCES 2+0

Objective

This course focuses on statistical methods for discrete data collected in public health, clinical and biological studies including survival analysis. This would enable the students to understand the principles of different statistical techniques useful in public health and clinical studies conducted.

Theory

UNIT I

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

UNIT II

Computing techniques, numerical methods, simulation and general implementation of biostatistical analysis techniques with emphasis on data applications. Analysis of survival time data using parametric and non- parametric models, hypothesis testing, and methods for analyzing censored (partially observed) data with covariates. Topics include

marginal estimation of a survival function, estimation of a generalized multivariate linear regression model (allowing missing covariates and/or outcomes).

UNIT III

Proportional Hazard model: Methods of estimation, estimation of

survival functions, time-dependent covariates, estimation of a multiplicative intensity model (such as Cox proportional hazards model) and estimation of causal parameters assuming marginal structuralmodels.

UNIT IV

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

UNIT V

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

Suggested Readings

Biswas S. 2007. *Applied Stochastic Processes. A Biostatistical and Population Oriented Approach*. Wiley Eastern Ltd.

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

Cox DR & Oakes D. 1984. *Analysis of Survival Data*. Chapman & Hall.
Hosmer DW Jr. &Lemeshow S. 1999. *Applied Survival Analysis:*

Regression Modeling or Time to Event. John Wiley.

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

Kleinbaum DG & Klein M 2005. *Survival Analysis. A Self Learning Text*.

Springer.

Kleinbaum DG & Klein M. 2005. *Logistic Regression*. 2nd Ed. Springer. Lee ET. 1992. *Statistical Methods for Survival Data Analysis*. John Wiley. Miller RG. 1981. *Survival Analysis*. John Wiley.

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

STAT577 STATISTICALECOLOGY 2+0

Objective

This course is meant for exposing the students to the importance and use of statistical methods in collections of ecological data, species-abundance relations, community classification and community

interpretation.

Theory

UNIT I

Ecological data, Ecological sampling; Spatial pattern analysis: Distribution methods, Quadrant-variance methods, Distancemethods.

UNIT II

Species-abundance relations: Distribution models, Diversity indices;

Species affinity: Niche-overlap indices, interspecific association, interspecificcovariation.

UNIT III

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

UNIT IV

Community interpretation: Classification Interpretation and Ordination Interpretation.

Suggested Readings

Gotelli NJ & Ellison AM. 2004.*A Primer of Ecological Statistics*

Pielou EC. 1970. *An introduction to Mathematical Ecology*. John Wiley.
Reynolds JF & Ludwig JA. 1988. *Statistical Ecology: A Primer on*

Methods and Computing. JohnWiley.

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

STAT551 MATHEMATICS- I 3+0

Objective

This course lays the foundation of all other courses of 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: 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

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.Integration of rational, irrational and trigonometric functions. Application of integration.

UNIT III

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

UNIT IV

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

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.

STAT 561 MATHEMATICS- II 2+0

Objective

This is another course that supports all other courses in 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, Trace of matrices 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. Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of vectors and 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 of India.

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

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

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 (2006). *Matrix Algebra Useful for Statistics* John Wiley, 2nd Ed.

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

COURSE CURRICULUM

SERVICE COURSES

(AGRIL. STATISTICS)

(For M.Sc. and Ph.D. programmes of other disciplines)

DIVISION OF STATISTICS & COMPUTER SCIENCE

FACULTY OF BASIC SCIENCES

Service Courses of Statistics

(For M.Sc. and Ph.D. programmes of other disciplines):

Course No.	Course title	Credit Hrs.	Sem.
STAT 501	MATHEMATICS FOR APPLIED SCIENCES	2+0	I
***STAT 502**	STATISTICAL METHODS FOR APPLIED SCIENCES	3+1	I
***STAT 511**	EXPERIMENTAL DESIGNS	2+1	II
***STAT 512**	BASIC SAMPLING TECHNIQUES	2+1	II
***STAT 521**	APPLIED REGRESSION ANALYSIS	2+1	III
***STAT 522**	DATA ANALYSIS USING STATISTICAL PACKAGES	2+1	III

**At least one course mandatory for all the students' pursuing M.Sc./Ph.D programme.*

STAT501 MATHEMATICS FOR APPLIED SCIENCES 2+0

Objective

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. The students would get an exposure to Linear Algebra, differentiation, integration and differential equations etc.

Theory

UNIT I

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

UNIT II

Vectors and vector spaces, Matrices notations and operations, laws of matrix algebra; transpose and inverse of matrix, Eigen values and Eigen vectors. Determinants - evaluation and properties of determinants, Solutions of Linear Equations.

UNIT III

Variables and functions, limits and continuity of specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, Differentiation of function of a function, derivatives of higher order, partial derivatives. Application of derivatives, determination of points of inflexion, maxima and minima.

UNIT IV

Integration, methods of integration, reduction formulae, definite and indefinite integral, Applications of integration in Agriculture, Differential Equations.

Suggested Readings

Franz E. Hohn (2013). Elementary Matrix Algebra, 3rd Ed., Kindle Edition Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*.

Springer.

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

Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley. Stewart J. 2007. *Calculus*. Thompson.

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

STAT502 STATISTICAL METHODS FOR APPLIED SCIENCES3+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

Box-plot, Descriptive statistics, Exploratory data analysis, Theory of probability, Random variable and mathematical expectation.

UNIT II

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

UNIT III

Introduction to theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression coefficients, Coefficient of determination, Fitting of quadratic models.

UNIT IV

Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomness of a sequence. Median test.

UNIT V

Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

Practical

Exploratory data analysis, 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 Correlation and regression analysis, fitting of Linear and Quadratic Model; Non- parametric tests. ANOVA: One way, Two Way, SRS

Suggested Readings

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

Goon AM, Gupta MK &Dasgupta B. 1983. Fundamentals of Statistics.

Vol. I. The World Press.

Hoel PG. 1971. *Introduction to Mathematical Statistics*. John Wiley.
Hogg RV & Craig TT. 1978. *Introduction to Mathematical Statistics*.

Macmillan.

Morrison DF. 1976. *Multivariate Statistical Methods*. McGraw Hill.

Robert V. Hogg, Joseph W. McKean, Allen T. Craig (2012). Introduction to Mathematical Statistics (7th Edition)

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

T.W. Anderson(2009) An Introduction to Multivariate Statistical Analysis, 3rd Ed . John Wiley

http://freestatistics.altervista.org/en/learning.php.http://www.statso

ft.com/textbook/stathome.html.

STAT511 EXPERIMENTAL DESIGNS 2+1

Objective

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students

would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

UNIT I

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

UNIT II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

UNIT IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

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; Analysis with missing data; Split plot and strip plot designs.

Suggested Readings

Cochran WG & Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley. Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. Springer. Douglas C. Montgomery (2012). Design and Analysis of Experiments, 8th Ed. John Wiley.

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

Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd. Nigam AK & Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.

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

www.drs.icar.gov.in.

STAT512 BASIC SAMPLING TECHNIQUES 2+1

Objective

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their 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 of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

UNIT II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

UNIT III

Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

UNIT IV

Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

Practical

Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.; simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and

systematic sampling; Estimation using ratio and regression estimators; Estimation using multistage design, double sampling.

Suggested Readings

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

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

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

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

William. G. Kochran.2007. Sampling Techniques. John Wiley & Sons Publication

William G. Cochran (2007).Sampling Techniques, 3rd Edition.John Wiley & Sons Publication

STAT521 APPLIED REGRESSION ANALYSIS 2+1

Objective

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multi collinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

Theory

UNIT I

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

UNIT II

Problem of correlated errors; Auto correlation; Heteroscedastic models, Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multi collinearity, Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

UNIT III

Diagnostic of multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation.

UNIT IV

Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

Practical

Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection; Handling of correlated errors, multi collinearity; Fitting of quadratic, exponential and power curves, fitting oforthogonal polynomials.

Suggested Readings

David G. Kleinbaum, Lawrence L. Kupper, Azhar Nizam(2007). Applied Regression Analysis and Other Multivariable Methods (Duxbury Applied) 4th Ed.

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

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

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

Koutsoyiannis A. 1978. *Theory of Econometrics*. MacMillan.

Kutner MH, Nachtsheim CJ &Neter J. 2004. *Applied Linear Regression Models*. 4th Ed. With Student CD. McGraw Hill.

STAT522 DATA ANALYSIS USING STATISTICAL PACKAGES 2+1

Objective

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students a hands on experience in the analysis of their research data. This course is useful to all disciplines.

Theory

UNIT I

Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II

Test for normality; Testing of hypothesis using chi-square, *t* and *F*

statistics and Z-test.

UNIT III

Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

UNIT IV

Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

UNIT V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

Practical

Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data. Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test for large samples - Chi-squares test, F test, one-way analysis of variance, Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components, Linear regression, Multiple regression, Regression plots, Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis - obtaining principal component.

Suggested Readings

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

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

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

Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall.

Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.

Cleveland WS. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.

Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley.

Erickson BH &Nosanchuk TA. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.

Snell EJ & Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman & Hall.

COURSE CURRICULUM

DOCTOR OF PHILOSOPHY

(AGRIL. STATISTICS)

DIVISION OF STATISTICS & COMPUTER SCIENCE

FACULTY OF BASIC SCIENCES

***Degree Programme*:** **Ph.D. (Agricultural Statistics)**

Minimum Credit Requirements

Subject	**Doctoral programme**
Major	12
Minor	06
Supporting	05

Seminar	02
Research	75
Total Credits	**100**
Compulsory Non Credit Courses*	05

* Offered to students not studied during M.Sc. Programme.

Courses and their contents to be offered for Ph. D. (Agril. Statistics)

Course No.	Course Title	Credit Hrs.	Semester
CORE COURSES			
STAT 601	ADVANCED DATA ANALYTICS	1+2	I
STAT 603	LINEAR MODELS	2+0	I
STAT 604	ADVANCED STATISTICAL METHODS	2+1	I
OPTIONAL COURSES			
STAT 605	MODELING TECHNIQUES FOR FORECASTING	2+1	I
STAT 606	STOCHASTIC PROCESSES	2+0	I
STAT 607	SURVIVAL ANALYSIS	2+0	I
STAT 608	SPATIAL STATISTICS	1+1	I
STAT 611	BAYSIAN INFERENCE	2+0	II
STAT 612	ADVANCED DESIGN OF EXPERIMENTS	2+1	II
STAT 613	ADVANCED SAMPLING TECHNIQUES	2+1	II
STAT 614	ADVANCED STATISTICAL GENETICS	2+1	II
STAT 615	ADVANCED TIME SERIES ANALYSIS	2+0	II
STAT 616	ADVANCED BIOINFORMATICS	2+0	II
STAT 617	ADVANCED ECONOMETRICS	2+0	II
STAT 618	RECENT ADVANCES IN THE FIELD OF SPECIALIZATION	1+0	II
SEMINAR			
STAT 691	SEMINAR I	0+1	I
STAT 692	SEMINAR II	0+1	II
RESEARCH			
STAT 699	RESEARCH	0+75	I-VI

Minor courses: From the subjects closely related to a student's major subject.

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work or necessary for building his/her overall competence.

STAT601 ADVANCED DATA ANALYTICS 1+2

Objective

This is an advanced course in Statistical Computing 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 and use of statistical packages.

Theory

UNIT I

Measures of association. Structural models for discrete data in two or more dimensions.

Estimation in complete tables. Goodness of fit, choice of a model. Generalized Linear Model for discrete data, Poisson and Logistic regression models. Log-linearmodels.

UNIT II

Elements of inference for cross-classification tables. Models for nominal and ordinal response.

UNIT III

Computational problems and techniques for robust linear regression, nonlinear and generalized linear regression problem, tree-structured regression and classification, cluster analysis, smoothing and function estimation, robust multivariate analysis.

UNIT IV

Analysis of incomplete data: EM algorithm, single and multiple imputations. Markov Chain, Monte Carlo and annealing techniques, Neural Networks, Association Rules and learning algorithms.

UNIT V

Linear mixed effects models, generalized linear models for correlated data (including generalized estimating equations), computational issues and methods for fitting models, and dropout or other missing data.

UNIT VI

Multivariate tests of linear hypotheses, multiple comparisons, confidence regions, prediction intervals, statistical power, transformations and diagnostics, growth curve models, dose-response models.

Practical

Analysis of qualitative data; Generalized linear for correlated data; Generalized linear models for discrete data; Robust methods of estimation and testing of non-normal data; Robust multivariate analysis; Cluster analysis; Analysis of Incomplete data; Classification and prediction using artificial neural networks; Markov Chain; Analysis of data having random effects using Linear mixed effects models; Analysis of data with missing observations; Applications of multiple comparison procedures; Building Simultaneous confidence intervals; Fitting of growth curve models to growth data; Fitting of dose-response curves and estimation of parameters.

Suggested Readings

Everitt BS & Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.

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

Gentle JE, Härdle W & Mori Y. 2004. *Handbook of ComputationalStatisti*

Han J &Kamber M. 2000. *Data Mining: Concepts and Techniques*.Morgan.

Hastie T, Tibshirani R & Friedman R. 2017. *The Elements of Statistical Learning: Data Mining, Inference and Prediction*. Springer. 2nd Ed.

Kennedy WJ & Gentle JE. 1980. *Statistical Computing*. Marcel Dekker.
Miller RG Jr. 1986. *Beyond ANOVA, Basics of Applied Statistics*. JohnWiley.

Rajaraman V. 1993. *Computer Oriented Numerical Methods*. Prentice-Hall.

Robert CP & Casella G. 2004. *Monte Carlo* Statistical *Methods*. 2nd Ed.Springer.

Ross S. 2000. *Introduction to Probability Models*. Academic Press. Simonoff JS. 1996. *Smoothing Methods in Statistics*. Springer.

Thisted RA. 1988. *Elements of Statistical Computing*. Chapman & Hall.
Venables WN & Ripley BD. 1999. *Modern Applied Statistics With S-Plus*. 3rd Ed. Springer.

Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
Design Resources Server: www.drs.icar.gov.in.

STAT602 SIMULATION TECHNIQUES 1+1

Objective

This course is meant for students who have a good knowledge in Statistical Inference and Statistical Computing. This course would prepare students for undertaking research in the area of simulation techniques andtheir applications to agriculturalsciences.

Theory

UNIT I

Uses and purposes of simulation; Classification of models. Generation and testing of random numbers, Review of simulation methods;
Implementation of simulation methods - for Discrete and continuous probability distribution,
sampling and resampling methods: theory and application of the jackknife and thebootstrap.

UNIT II

Randomization tests, analysis using computer software packages.
Simulating multivariate distributions, MCMC methods and Gibbs sampler.

UNIT III

Simulation of generalized linear models and time series models, Simulated data sets to be analyzed using popular computer software packages

UNIT IV

Stochastic simulation: Markov Chain, Monte Carlo, Hastings-Metropolis algorithms, critical slowing-down and remedies, auxiliary variables, simulated tempering, reversible- jump MCMC and multi-grid methods.

Practical

Simulation from various probability models; Resampling methods, jackknife and the bootstrap; Randomization tests; Simulating multivariate distributions, MCMC methods and Gibbs sampler; Simulated data sets to be analyzed using popular computer software packages; Markov Chain, Monte Carlo, Gibbs' sampling; Reversible- jump MCMC and multi-grid methods.

Suggested Readings

Averill ML. 2017. *Simulation, Modeling and Analysis*. Tata McGraw Hill.

Balakrishnan N, Melas VB &Ermakov S. (Ed.). 2000. *Advances in Stochastic Simulation Methods*.Basel-Birkhauser.

Banks J. (Ed.). 1998. *Handbook of Simulation: Principles, Methodology, Advances, Applications and Practice*. JohnWiley.

Brately P, Fox BL &Scharge LE. 1987. *A Guide to Simulation*. Springer.

Davison AC &Hinkley DV. 2003. *Bootstrap Methods and their Application*. Cambridge Univ. Press.

Gamerman D, Lopes HF & Lopes HF. 2006. *Markov Chain* Monte *Carlo:Stochastic Simulation for Bayesian Inference*. CRC Press.

Gardner FM & Baker JD. 1997. *Simulation Techniques Set*. John Wiley.

Gentle JE. 2005. *Random Number Generation and Monte Carlo Methods*.

Springer.

Janacek G & Louise S. 1993. *Time Series: Forecasting, Simulation,Applications*.Ellis Horwood Series in Mathematics and Its Applications.

Kleijnen J &Groenendaal WV. 1992. *Simulation: A Statistical Perspective*.

John Wiley.

Kleijnen J. 1974 (Part I), 1975 (Part II). *Statistical Techniques in Simulation*. Marcel Dekker.

Law A & Kelton D. 2000. *Simulation Modeling and Analysis*. McGraw Hill.

Press WH, Flannery BP, Tenkolsky SA &Vetterling WT. 1986. *Numerical Recipes*. Cambridge Univ.Press.

Ripley BD. 1987. *Stochastic Simulation*. John Wiley. Ross SM. 1997. *Simulation*. JohnWiley.

STAT603 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. 2012. *Linear Algebra and Linear Models*. Springer-Verlag.

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

Duxbury, North Scituate.

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

Rao, C. R. 2001. *Linear Inference and its Application*. Wiley Eastern.
Searle, S. R. 1998. *Variance Components*. John Wiley.

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

Seber, G.A. F. 1996. *The Linear Hypothesis: A General Theory*.

Griffin, Charles and Co. Ltd. Sheffe, H. 1999. *Analysis of Variance*. John Wiley.

STAT604 ADVANCED STATISTICAL METHODS 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 this area. This also helps prepare students for applications of this important subject to agriculturalsciences.

Theory

UNIT I

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

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. Order statistics, distribution of rth order statistics, joint distribution of several order statistics andtheir functions, marginal distributions of order statistics, distribution of range, median etc.

UNIT IV

Fitting of a generalized linear model, mixed model and variance components estimation, MINQUE, MIVQUE, REML.

Practical

Fitting of truncated distribution, Fitting of Pearsonian curves, Analysis of association between attributes, categorical data. 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

Chatterjee S, Hadi A & Price B. 2013. *Regression Analysis by Examples*. 5th Ed. John Wiley.

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

Rao CR. 2009. *Linear Statistical Inference and its Applications*. 2nd Ed.John Wiley.

Searle SR, Casella G & McCulloch CE. 1992. *Variance Components*. John Wiley.

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

STAT 605 MODELING TECHNIQUES FOR FORECASTING 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 empirical and mechanistic models and nonlinear estimation and the replications in different disciplines of agricultural sciences.

Theory

UNIT I

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

UNIT II

Nonlinear estimation: Least squares for nonlinear models, Methods for estimation of parameters like Linearization, Steepest, and Levenberg-Marquardt's Parameterization.

UNIT III

Two-species systems. Lotka-Volterra, Leslie-Gower and Holling-Tanner non-linear prey-predator models. Volterra's principle and its applications.Gauss competition model.

UNIT IV

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

UNIT V

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 VI

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

Practical

Fitting of mechanistic non-linear models; Application of Schaefer and Fox non-linear models; Fitting of compartmental models.Fitting of forecast

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

Suggested Readings

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

Efromovich S. 1999. *Nonparametric Curve Estimation*. Springer.

Fan J & Yao Q. 2003. *Nonlinear Time Series-Nonparametric and Parametric Methods*. Springer.

France J &Thornley JHM. 1984. *Mathematical Models in Agriculture*.

Butterworths.

Harvey AC. 1996. *Forecasting, Structural Time Series Models and the Kalman Filter*. Cambridge Univ. Press.

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

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

Thornley J.&France J. (2006). *Mathematical Models in Agriculture: Quantitative Methods for the Plant, Animal and Ecological Sciences* (Cabi) 2nd Ed.

STAT 606 STOCHASTIC PROCESSES 2+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

Introduction to stochastic process - 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

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

UNIT III

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

UNIT IV

Stochastic process in biological sciences: Markov models in population genetics, compartmental analysis. Simple deterministic and stochastic epidemic model. General epidemic models-Karmack and McKendrick's threshold theorem. Recurrent epidemics.

UNIT V

Elements of queueing process; the queuing model M/M/1: steady state behaviors. Birth and death process in queuing theory- Multi channel models. Network of Markovian queuing system.

UNIT VI

Branching process: Galton-Watson branching process. Mean and variance of size of nth generation, probability of ultimate extinction of a branching process. Fundamental theorem of branching process and applications.

UNIT VII

Wiener process- Wiener process as a limit of random walk. First passage time for Wiener process. Kolmogorov backward and forward diffusion equations and their applications.

Suggested Readings

Adke SR &Manjunath SM. 1984. *Finite Markov Processes*. John Wiley.

Bailey NTJ. 1964. *Elements of Stochastic Processes with Applications to the Natural Sciences*. Wiley Eastern.

Bartlett MS. 1955. *Introduction to Stochastic Processes*. Cambridge Univ. Press.

Basawa IV &Prakasa Rao BLS. 1980. *Statistical Inference for Stochastic Processes*. Academic Press.

Bharucha-Reid AT. 2012. *Elements of the Theory of Markov Processes and their Applications*. McGraw Hill.

Bhat BR. 2000. *Stochastic Models; Analysis and Applications*. New Age. Draper NR & Smith H. 1981. *Applied Regression Analysis*. Wiley Eastern. France J &Thornley JHM. 1984. *Mathematical Models in Agriculture*. Butterworths.

Lawler GF. 2006. *Introduction to Stochastic Processes*. Chapman & Hall. 2nd Ed.

Medhi J. 2001. *Stochastic Processes*. 2nd Ed. Wiley Eastern.

Prakasa Rao BLS &Bhat BR.1996. *Stochastic Processes and Statistical Inference*. New Age.

Ratkowsky DA. 1983. *Nonlinear Regression Modelling: a Unified Practical Approach*. Marcel Dekker.

Ratkowsky DA. 1990. *Handbook of Nonlinear Regression Models*. Marcel Dekker.

Seber GAF & Wild CJ. 1989. *Non-linear Regression*. John Wiley.

STAT607 SURVIVAL ANALYSIS 2+0

Objective

The course deals with the study of demographic profiles and survival times. In-depth statistical properties and analysis is an important component of this course.

Theory

UNIT I

Measures of Mortality and Morbidity: Ratios and proportions, rates of continuous process, rates of repetitive events crude birth rate, Mortality measures used in vital statistics relationships between crude and age specific rates, standardized mortality ratios evaluation of person-year of exposed to risk in long term studies, prevalence and incidence of a disease, relative risk and odds ratio. Survival Distribution: Survival functions, hazard rate, hazard function, review of survival distributions: exponential, Weibull, Gamma, Rayleigh, Pareto, Lognormal~ IFR and TFRA, Gompertz and Makeham. Gompertz and logistic distributions. Parametric (m.l.e) estimation. Types of Censoring: Type I, Type II, random and other types of censoring, right and left truncated distributions. Expectation and variance of future life time, series and parallel system of failures. Life Tables: Fundamental and construction.

UNIT II

Complete Mortality data, Estimation of Survival Function: Empirical survival function, estimation of survival function from grouped mortality data, joint distribution of the number of deaths, distribution of the estimation P_i covariance of estimate, estimation of curves of deaths and central death rate and force of mortality rate. Incomplete Mortality data (non-parametric models): Actuarial method, m.1.e method, moment and reduced sample method of estimation and their comparison. Product limit (Kaplan-Meier) method and cumulative hazard function (CHF) of estimation of survival function.

UNIT III

Fitting Parametric Survival Distribution: Special form of survival function

cumulative hazard function (CHF) plots, Nelson's method of ungrouped data, construction of the likelihood function for survival data, least squares fitting, fitting a Gompertz distribution to grouped data. Some tests of Goodness of fit: Graphical, Kolmogorov-Smirnov statistics for complete, censored and truncated data, Chi-Square test and Anderson- Darling A^2- statistics. Comparison of Mortality Experiences: Comparison of two life tables, some distribution- free methods (two samples) for ungrouped data, Two samples Kolmogorov-Smirnov test, Wilcoxon test for complete data and modified Wilcoxon test for incomplete data .Gilbert and Gehan's test, mean and variance of Wilcoxon statistics, generalization of Gehan's test. Testing for Consistent Differences in Mortality: Mantel-Haenszel and log rank test. Generalized Mantel-Haenszel test (k-sample).

UNIT IV

Concomitant Variables: General parametric model for hazard function with observed concomitant variables. Additive and multiplicative models of hazard rate functions. Estimating multiplicative models, selection of concomitant variables. Logistic linear model, Concomitant Variable regarded as random variable. Age of onset distributions: Models of onset distributions and their estimation. Gompertz distribution, parallel system and Weibull distribution, Fatal short models of failure. Two component series system.

UNIT V

Interval Censoring Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter- relations.Concept of COX regression Stochastic Epidemic Models: Simple epidemic models, general epidemic model definition and concept (without derivation). Duration of an epidemic.

Suggested Readings

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

Blackwell.

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

Blackwell.

Biswas, S. 2007.*Applied Stochastic Processes*: A Biostatistical and Population Oriented Approach, 2nd Ed., New Central Book Agency.

Collett D. 2014. *Modeling Survival Data in Medical Research*. Chapman & Hall. 3rd Ed.

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 Jr. &Lemeshow S. 1999. *Applied Survival Analysis:*

Regression Modeling or Time to Event. John Wiley.

Indrayan, A. 2008. *Medical Biostatistics*, 2nd Ed. Chapman and Hall/CRC.
Lee ET. 1980. *Statistical Methods for Survival Data Analysis*. Lifetime Learning Publ.
Kalbfleisch JD & Prentice. RL 2002. *The Statistical Analysis of Failure Time Data*. 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*. Springer.

STAT 608 SPATIAL STATISTICS 1+1

Objective

This is a course on Spatial statistics aims at exposing the students to some advanced level spatial methods and their applications to agricultural situations.

Theory

UNIT I

Spatial Analysis and types of spatial data; Visualizing Spatial Data – Exploratory data Analysis.

UNIT II

Spatial Relationship- Random forest, spatially autocorrelated data, weight matrix, measures of spatial Auto-correlation – Moran's I & Geary's C; Measuring of autocorrelation of spatially continuous data.

UNIT III

Spatial Sampling – Methods and procedures, Statistical Analysis of Spatial Point Process – homogenous Poisson Process, Spatial interpolation – non-statistical methods; Variogram modelling; Spatial Prediction – Simple Kriging, Co-kriging;

UNIT IV

Modelling Areal data – Autoregressive and spatial regression models and model diagnostics. Examples of Spatial Data analysis in Agriculture– Disease Mapping; Incorporating spatial effects in Agricultural Field experiments

Practical

Spatial Data – Import, export; Spatial Classes in R; Visualizing Spatial Data; Spatial Auto-correlation; Spatial Sampling, Spatial Interpolation, Spatial Autoregressive Models, Spatial Regression Model

Suggested Readings

Cressie, NAC. 1993.*Statistics for Spatial Data*. Revised Edition. JohnWiley

Richard EP. 2018. *Spatial Data Analysis in Ecology and Agriculture Using R*, 2nd Ed.

Roger S. Bivand,E Pebesma J. and Rubio BG (2008). *Applied Spatial Data Analysis using R.* Springer-Verlog.

STAT611 BAYSIAN INFERENCE 2+0

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

Introduction and history and criticism of Bayesian Approach; Subjective interpretation of Probability, Review of Bayes Theorem, Sufficiency, Likelihood Principle.

UNIT II

Subjective Prior distribution of a parameter; Posterior Distribution of parameters using Bayes Theorem

UNIT III

Informative and non-informative priors for Location and scale; Conjugate families –Discrete and Continuous and interpretation of Hyper-parameters of conjugates.

UNIT IV

Non-informative, improper and invariant priors for location and scale and in general settings.

UNIT V

Bayesian Point Estimation – squared error loss, absolute error loss etc. Bayesian Interval Estimation – Credible Interval, interpretation and comparison with frequentist confidence Intervals

UNIT VI

Bayesian Hypothesis Testing - Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Prior odds, Posterior odds, Bayes factor for various types of testing hypothesis problems

UNIT VII

Bayesian Prediction; Numerical and Monte-Carlo Integrations

UNITVIII

Applications of Bayesian Inference - Bayesian Data Analysis

Suggested Readings

Berger, J. O. 1985. *Statistical Decision Theory and Bayesian Analysis*, Springer Verlag.

Box, GP. and Tiao, GC. 1992. *Bayesian Inference in StatisticalAnalysis*,Addison – Wesley

Pilon CD. 2015. *Bayesian Methods for Hackers: Probabilistic Programming and Bayesian Inference* (Addison-Wesley Data and Analytics)

STAT612 ADVANCED DESIGN OF EXPERIMENTS 2+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 agriculturalsciences.

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, Designs for test treatment – control(s) comparisons; Nested block designs, Mating designs.Structurally Incomplete block designs

UNIT II

General properties and analysis of two-way heterogeneity designs, Youden type designs, generalized Youden designs, Pseudo Youdendesigns., Designs for two sets of treatments.

UNIT III

Balanced factorial experiments - characterization and analysis (symmetrical and asymmetrical factorials). Factorial experiments with extra treatment(s). Orthogonal arrays, Mixed orthogonal arrays, balanced arrays, Fractional replication, Resolution plans, Regular and irregular fractions.

UNIT IV

Response surface designs - Symmetrical and asymmetrical factorials, Response optimization and slope estimation, Blocking, Canonical analysis and ridge analysis, CCD, Box-Jenkins, Experiments with mixtures: design and analysis. Experiments with qualitative cum quantitative factors.

UNIT V

Optimality criteria and optimality of designs, robustness of designs against loss of data, outliers, etc. Diagnostics in design of experiments.

Practical

Analysis of block designs, Analysis of Latin square type designs, group divisible designs, triangular designs, lattice designs. Analysis of fractional replications of factorial experiments, analysis of asymmetrical factorials and block designs with factorial structure. Analysis of second order response surface designs.

Suggested Readings

Chakraborti MC. 1962. *Mathematics of Design and Analysisof Experiments*. Asia Publ.House.

Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. pringer. Dey A &Mukerjee R. 1999. *Fractional Factorial Plans*. John

Wiley.

DeyA 1986. *Theory of Block Designs*. Wiley Eastern.

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

Hedayat AS, Sloane NJA &Stufken J. 1999. *Orthogonal Arrays: Theory and Applications*. Springer.

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

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

Montgomery DC. 2005. *Design and Analysis of Experiments*. John Wiley. Ogawa J. 1974. *Statistical Theory of the Analysis of Experimental*

Designs.
Marcel
Dekker.

Parsad R, Gupta VK, Batra PK, Satpati SK & Biswas P. 2007. *Monograph on -designs*. IASRI, New Delhi.

Raghavarao D. 1971. *Construction and Combinatorial Problems in*

Design of Experiments. JohnWiley.

Shah KR & Sinha BK. 1989. *Theory of Optimal Designs. Lecture notes in Statistics*. Vol. 54.Springer.

Sharma M.K 2012. *Design and Analysis of Experiments*. Kindle Ed. 1st Ed.

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

Design Resources Server: www.drs.icar.gov.in.

STAT613 ADVANCED SAMPLING TECHNIQUES 2+1

Objective

This is an advanced course in Sampling Techniques that aims at describing some advanced level topics for students who wish to pursue research in Sampling Techniques. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to Statistical System in thecountry.

Theory

UNIT I

Optimum Stratification, two-way stratification, collapsed strata, Controlled selection, Use of combinatorics in controlled selection, Systematic sampling in two dimensions. Sampling with varying probabilities without replacement, Horvitz – Thompson estimator

UNIT II

Variance estimation in complex surveys. Taylor's series linearization, balanced repeated replication, Jackknife and bootstrap methods.Ordered and unordered estimators, Sampling strategies, Midzuno-Sen, Rao- Hartley-Cochran,πPS Sampling: procedures such as Brewer, Durbin and Sampford,

UNIT III

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 IV

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

Practical

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

Suggested Readings

Berger JO. 1993. *Statistical Decision Theory and Bayesian Analysis*.Sringer.

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

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

Des Raj &Chandhok P. 1998. *Sample Survey Theory*. Narosa Publ. House. Ghosh M &Meeden G. 1997. *Bayesian Method for Finite Population Sampling*. *Monograph on Statistics and Applied Probability*. Chapman &Hall.

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

Rao JNK. 2003. *Small Area Estimation*. John Wiley.

Sarndal CE, Swensson B &Wretman JH. 1992. *Model Assisted Survey Sampling*. Springer.

STAT614 ADVANCED STATISTICAL 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 populationsize.

UNIT III

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 IV

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 V

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

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

uggested Readings

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

Ewens WJ. 1979. *Mathematical Population Genetics*. Springer.
Falconer DS. 1985. *Introduction to Quantitative Genetics*. ELBL.
Fisher RA. 1949. *The Theory of Inbreeding*. Oliver & Boyd.

Fisher RA. 1958. *The Genetical Theory of Natural Selection*. Dover Publ.

Haldane JBS. 1932. *The Causes of Evolution*. Harper & Bros.
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. 1958. *The Genetic Theory of Selection*. John Wiley.

Li CC. 1982. *Population Genetics.* The University of Chicago Press.
Mather K & Jinks JL. 1982. *Biometrical Genetics*. Chapman & Hall.
Mather K. 1951. *The Measurement of Linkage in Heredity*.

Methuen. Nagilaki T. 1992. *Introduction to Theoretical PopulationGenetics*.Springer.

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

Nielsen R, Montgomery S. 2013. *An Introduction to Population Genetics: Theory and Applications* 1st Ed.

STAT615 ADVANCED TIMESERIESANALYSIS 2+0

Objective

This is an advanced course in Time Series Analysis 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 agriculturalsciences.

Theory

UNIT I

Multivariate time series: modelling the mean, stationary VAR models: properties, estimation, analysis and forecasting, VAR models with elements of nonlinearity, Non-stationary multivariate time series: spurious regression, co-integration, Vector Error Correction Model (VECM).

UNIT II

Volatility: The class of ARCH and GARCH models; Extensions of GARCH models: TGARCH, IGARCH, PGARCH, EGARCH, GJR-
GARCH, ARCH and GARCH model with-t distributed error; ARCD (Auto-Regressive Conditional Density), Multivariate GARCH model: estimation, analysis and forecasting, stochastic volatility.

UNIT III

Structural time-series modelling: State space models, Kalman filter, Local level model, Local linear trend model, Seasonal models, Cyclical models. Threshold and Functional coefficient autoregressive models, Structural Break in time series.

UNIT IV

Fuzzy time series models, Artificial Neural Network (ANN) methodology, Support vector machines, Wavelets for time series analysis, combinations of time series models.

Suggested Readings

Box GEP, Jenkins GM &Reinsel GC. 2015. *Time Series Analysis: Forecasting and Control*. 5th Ed. John Wiley.

Brockwell PJ & Davis RA. 1991. *Time Series: Theory and Methods*. 2nd Ed.Springer.

Chatfield C. 2004. *The Analysis of Time Series: An Introduction*. 6th Ed.Chapman& Hall/CRC.

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

Singh, P. 2016. *Applications of Soft Computing in Time Series Forecasting: Simulation and Modeling Techniques*. Springer International Publishing AG

Tong H. 1995. *Nonlinear Time Series: A Dynamical System Approach*.Oxford Univ. Press.

Vapnik, V. N. (2000). *The Nature of Statistical Learning Theory*. Springer- Verlag, New York.

Percival, D.B. and Walden, A.T. (2000). *Wavelet Methods for Time-Series Analysis.* Cambridge University Press, U.K

STAT616 ADVANCEDBIOINFORMATICS 2+1

Objective

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

EM algorithm and other statistical methods to discover common motifs in biosequences. Concepts in phylogeny. Gene prediction based on codons, Decision trees, Clustering Techniques, Classificatory analysis, Neural

Networks, Genetic algorithms, Pattern recognition, Hidden Markovmodels.

UNIT II

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

UNIT III

Analysis of one DNA sequence (Modeling signals in DNA; Analysis of patterns; Overlaps and Generalizations), Analysis of multiple DNA or protein sequences (Alignment algorithms – Gapped global comparisons and Dynamic programming; use of linear gap models; protein sequences and substitution matrices – BLOSUM, PAM; Multiple sequences), BLAST (Comparison of two aligned sequences – Parameter calculation; Choice of a score; Bounds for P-value; Normalized and Bit scores, Karlin – Altschul sum statistic; comparison of two unaligned sequences; Minimum significance Lengths).

UNIT IV

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

UNIT V

Modeling protein families; Multiple sequence alignments; Pfam; Gene finding), Computationally intensive methods (Classicalestimation methods; Bootstrap estimation and Confidence Intervals; Hypothesis testing; Multiple Hypothesis testing), Evolutionary models (Models of Nucleotide substitution; Discrete time models – The Jukes-Cantor Model, The Kimura Model, The Felsenstein Model; Continuous-time models),

UNITVI

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 – Backpropagation; 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.

Practical

Genomic databases and analysis of high-throughput data sets, BLAST and related sequencecomparison methods. Statistical methods to discover common motifs in biosequences. Multiplealignment and database search using motif models, clustalw, classificatory analysis, neuralnetworks, genetic algorithms, pattern recognition, Hidden Markov models. Computationalanalysis of protein sequence. Expression profiling by microarray/gene chip, proteomics. Modellingand prediction of structure of proteins. Bayesian techniques and use of Gibbs Sampling. Analysisof DNA microarray experiments. Analysis of one DNA sequence, multiple DNA or proteinsequences. Computationally intensive methods, multiple hypothesis

testing, Phylogenetic treeestimation, Analysis of SNPs and haplotypes.

Suggested Readings

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

Baxevanis AD & Francis BF. (Eds.). 2004. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. John Wiley.

Duda RO, Hart PE & Stork DG. 1999. *Pattern Classification*. John Wiley.

Ewens WJ & Grant GR. 2001. *Statistical Methods in Bioinformatics*.Springer.

Jones NC &Pevzner PA. 2004. *Introduction to Bioinformatics Algorithms*. The MIT Press.

Koskinen T. 2001. *Hidden Markov Models for Bioinformatics*. Kluwer.

Krane DE & Raymer ML. 2002. *Fundamental Concepts of Bio-informatics*. Benjamin / Cummings.

Krawetz SA &Womble DD. 2003. *Introduction to Bioinformatics: A Theoretical and Practical Approach*. Humana Press.

Lesk AM. 2002. *Introduction to Bio-informatics*. Oxford Univ. Press.

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

Percus JK. 2001. *Mathematics of Genome Analysis*. Cambridge *Univ*.Press.

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

Tisdall JD. 2001. *Mastering Perl for Bioinformatics*. O'Reilly & Associates.

Wang JTL, Zaki MJ, Toivonen HTT &Shasha D. 2004. *Data Mining in Bioinformatics*. Springer.

Wu CH &McLarty JW. 2000. *Neural Networks and Genome Informatics*.Elsevier.

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

Yang MCC. 2000. *Introduction to Statistical Methods in Modern Genetics*.Taylor & Francis.

STAT617 ADVANCEDECONOMETRICS 1+1

Objective

This is a course on Econometrics aims at exposing the students to some advanced level econometric methods and their applications to agricultural situations.

Theory

UNIT I

Quantile regression, binary quantile regression, extreme values, copula, loss functions, Point and interval forecasting, unconditional and conditional forecasting, forecasting with serially correlated errors, bootstrap: asymptotic expansion, bootstrap consistency, asymptotic refinement, recent developments for dependent timeseries. Co integration analysis.

UNIT II

Multivariate time series: modelling the mean, stationary VAR models: properties, estimation, analysis and forecasting, VAR models with elements of nonlinearity, Non-stationary multivariate time series: spurious regression, co-integration, common trends; Volatility: Modelling the variance, The class of ARCH models: properties, estimation, analysis and forecasting, stochastic volatility, realizedvolatility.

UNIT III

Basic Concepts of Bayesian Inference, Probability and Inference, Posterior Distributions and Inference, Prior Distributions. The Bayesian linear model and autoregressive (AR) processes; Model selection with marginal likelihoods and fractional priors, Comparison of Bayesian Methods with Classical approaches, Bayes risk and their applications, and Sample Selection Monte Carlo integration, importance sampling and Gibbs sampling, The Regression Model with General Error Covariance Matrix, Qualitative Choice Models, Bayesian information criterion (BIC), Markov Chain Monte Carlo (MCMC) Model Composition and stochastic search variable selection, BUGS [Bayesian Inference Using Gibbs Sampling] , BUCC [Bayesian Analysis, Computation and Communication].

Practical

Fitting of equation with serially correlated errors, ordinary least-squares and generalized least squares methods of estimation. Non-stationary multivariate time series analysis. Fitting of The Regression Model with General Error Covariance Matrix, Qualitative Choice Models, Bayesian information criterion (BIC), Markov Chain Monte Carlo (MCMC) Model Composition and stochastic search variable selection, BUGSFitting of ARCH model.

Suggested Readings

Banerjee A, Dolado J, Galbraith J & Hendry DF. 1993. *Co-integration, Error Correction, and the Econometric Analysis of Nonstationary Data*. Oxford Univ. Press.

Bauwens L, Lubrano M & Richard JF. 1999. *Bayesian Inference in Dynamics of Econometric Models.* Oxford Univ. Press.

Carlin BP & Louis TA. 2008. *Bayes and Empirical Bayes Methods forData Analysis*. Chapman &Hall.

Gilks WR, Richardson S &Spiegelhalter D. 1996. *MCMC in Practice*.Chapman & Hall.

Greenberg E. 2012. *Introduction to Bayesian Econometrics*. Cambridge Univ. Press.

Hamilton JD. 1994. *Time Series Analysis*. Princeton Univ. Press.

Judge GG, Griffith WE, Hill RC, Lee CH &Lutkepohl H. 1985. *The Theory and Practice of Econometrics*. 2nd Ed. JohnWiley.

Koop G, Poirier D & Tobias J. 2007. *Bayesian Econometric Methods*.Cambridge Univ. Press.

Koop G. 2003. *Bayesian Econometrics*. John Wiley.
LancasterA.2004.

AnIntroductiontoModernBayesianEconometrics.Blackwell.

Pindyck RS &Rubinfeld DL. 1981. *Econometric Models and Economic Forecasts*. McGraw Hill.

STAT618 RECENT ADVANCES IN THE FIELD OF SPECIALIZATION 1+0

Objective

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

Theory

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

Suggested Readings

Recent journals related to the research works.