



Course Title with Credit Load M.Sc. in Agricultural Statistics

Course Code	Course Title	Credit Hours	Semester
*STAT 552	Probability Theory	2+0	I
*STAT 553	Statistical Methods	2+1	I
*STAT 562	Statistical Inference	2+1	II
*STAT 563	Design of Experiments	2+1	II
*STAT 564	Sampling Techniques	2+1	II
*STAT 565	Statistical Genetics	2+1	II
*STAT 571	Multivariate Analysis	2+1	III
*STAT 572	Regression Analysis	1+1	III
*STAT 573	Statistical Computing	1+1	III
STAT 591	Seminar	0+1	III
STAT 599	Research	0+30	II-IV
STAT 551	Mathematics-I	3+0	I
STAT 554	Actuarial Statistics	2+0	I
STAT 555	Bioinformatics	2+0	I
STAT 556	Econometrics	2+0	I
STAT 561	Mathematics-II	2+0	II
STAT 566	Statistical Quality Control	2+0	II
STAT 567	Optimization Techniques	1+1	II
STAT 574	Time Series Analysis	1+1	III
STAT 575	Demography	2+0	III
STAT 576	Statistical Methods for Life Sciences	2+0	III
STAT 577	Statistical Ecology	2+0	III
Supporting Courses			
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

*Core Courses



Course Contents

M.Sc. in Agricultural Statistics

- I. Course Title** : Mathematics for Applied Sciences
II. Course Code : STAT 501
III. Credit Hours : 2+0
IV. Aim of the course

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.

V. 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.

VI. Suggested Reading

- Hohn FE. 2013. *Elementary Matrix Algebra*, 3rd Ed., Kindle Edition
- Harville D.A. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.
- Hohn F.E. 1973. *Elementary Matrix Algebra*. Macmillan.
- Searle S.R. 1982. *Matrix Algebra Useful for Statistics*. John Wiley. Stewart J. 2007. *Calculus*. Thompson.
- Thomas G.B. Jr. and Finney R.L. 1996. *Calculus*. 9th Ed. Pearson Edu.

- I. Course Title** : Statistical Methods for Applied Sciences
II. Course Code : STAT 502
III. Credit Hours : 3+1
IV. Aim of the course

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.

V. 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.

VI. 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.

VII. Suggested Reading

- Goon A.M, Gupta M.K and Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.
- Goon A.M, Gupta M.K. and Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.
- Hoel P.G. 1971. *Introduction to Mathematical Statistics*. John Wiley.
- Hogg R.V and Craig T.T. 1978. *Introduction to Mathematical Statistics*. Macmillan.
- Morrison D.F. 1976. *Multivariate Statistical Methods*. McGraw Hill.
- Hogg RV, McKean JW, Craig AT. 2012. *Introduction to Mathematical Statistics* 7th Edition.
- Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.
- Anderson TW. 2009. *An Introduction to Multivariate Statistical Analysis*, 3rd Ed. John Wiley



- <http://freestatistics.altervista.org/en/learning.php>.
- <http://www.statsoft.com/textbook/stathome.html>.

I. Course Title : Experimental Designs

II. Course Code : STAT 511

III. Credit Hours : 2+1

IV. Aim of the course

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.

V. 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.

VI. 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.

VII. Suggested Reading

- Cochran WG and Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.
- Dean AM and Voss D. 1999. *Design and Analysis of Experiments*. Springer.
- Montgomery DC. 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 and 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.



- I. Course Title** : **Basic Sampling Techniques**
II. Course Code : **STAT 512**
III. Credit Hours : **2+1**

IV. Aim of the course

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.

V. 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.

VI. 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.

VII. Suggested Reading

- Cochran WG. 1977. *Sampling Techniques*. John Wiley.
- Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D, Singh P and Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.
- Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Cochran WG. 2007. *Sampling Techniques*, 3rd Edition. John Wiley & Sons Publication

- I. Course Title** : **Applied Regression Analysis**
II. Course Code : **STAT 521**
III. Credit Hours : **2+1**

IV. Aim of the course

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.

V. 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.

VI. 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 of orthogonal polynomials.

VII. Suggested Reading

- Kleinbaum DG, Kupper LL, Nizam A. 2007. *Applied Regression Analysis and Other Multivariable Methods* (Duxbury Applied) 4th Ed.
- Draper NR and Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- Ezekiel M. 1963. *Methods of Correlation and Regression Analysis*. John Wiley.
- Koutsoyiannis A. 1978. *Theory of Econometrics*. MacMillan.
- Kutner MH, Nachtsheim CJ and Neter J. 2004. *Applied Linear Regression Models*. 4th Ed. With Student CD. McGraw Hill.

- I. Course Title : Data Analysis Using Statistical Packages
II. Course Code : STAT 522
III. Credit Hours : 2+1

IV. Aim of the course

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.



V. 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.

VI. 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.

VII. Suggested Reading

- Anderson C.W. and Loynes R.M. 1987. *The Teaching of Practical Statistics*. John Wiley.
- Atkinson A.C. 1985. *Plots Transformations and Regression*. Oxford University Press.
- Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmont, California.
- Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall. Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.
- Cleveland W.S. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.
- Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley.
- Erickson B.H. and Nosanchuk T.A. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.
- Snell E.J. and Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman and Hall.
- Sprent P. 1993. *Applied Non-parametric Statistical Methods*. 2nd Ed. Chapman & Hall.
- Tufte ER. 1983. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Conn.
- Velleman PF and Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. Duxbury Press.
- Weisberg S. 1985. *Applied Linear Regression*. John Wiley.
- Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall.



- Wetherill GB. 1986. *Regression Analysis with Applications*. Chapman & Hall.
- Cleveland WS. 1994. *The Elements of Graphing Data*, 2nd Ed., Chapman & Hall
- <http://freestatistics.altervista.org/en/learning.php>.
- <http://freestatistics.altervista.org/en/stat.php>.
- http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
- <http://www.stat.sc.edu/~grego/courses/stat706/>.
- www.drs.icar.gov.in.

I. Course Title : Mathematics-I

II. Course Code : STAT 551

III. Credit Hours : 3+0

IV. Aim of the course

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.

V. 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.

VI. Suggested Reading

- 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. and Finney RL. 1996. *Calculus*. 9th Ed. Pearson Edu.



- I. Course Title** : Probability Theory
II. Course Code : STAT 552
III. Credit Hours : 2+0

IV. Aim of the course

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

V. Theory

Unit I

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

Unit II

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

Unit III

Conditional expectation and conditional variance. Characteristic function and its properties. Inversion and uniqueness theorems. Chebyshev, Markov, Cauchy-Schwartz, Sequence of random variables and modes of convergence (convergence in distribution in probability, almost surely, and quadratic mean) and their interrelations.

Unit IV

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

VI. Suggested Reading

- Ash RB. 2000. *Probability and Measure Theory*. 2nd Ed. Academic Press. Billingsley P. 1986. *Probability and Measure*. 2nd Ed. John Wiley.
- Capinski M and 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 JZ. 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.

- I. Course Title** : Statistical Methods
II. Course Code : STAT 553
III. Credit Hours : 2+1

IV. Aim of the course

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.

V. 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 and regression.

Unit IV

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

Unit V

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

VI. 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.

VII. Suggested Reading

- Agresti, A. 2012. *Categorical Data Analysis* 3rd Ed. John Wiley.
- Arnold BC, Balakrishnan N and Nagaraja HN. 1992. *A First Course in Order Statistics*. JohnWiley.
- David HA and Nagaraja HN. 2003. *Order Statistics*. 3rd Ed. John Wiley.
- Dudewicz EJ and Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.
- Huber PJ. 1981. *Robust Statistics*. John Wiley.
- Johnson NL, Kotz S and Balakrishnan N. 2000. *Continuous Univariate Distributions*. JohnWiley.
- Johnson NL, Kotz S and Balakrishnan N. 2000. *Discrete Univariate Distributions*. JohnWiley.
- Marek F.1963. *Probability Theory and Mathematical Statistics*. John Wiley.
- Rao CR. 1965. *Linear Statistical Inference and its Applications*. John Wiley.
- Rohatgi VK and 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

- I. Course Title** : **Actuarial Statistics**
II. Course Code : **STAT 554**
III. Credit Hours : **2+0**

IV. Aim of the course

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.

V. 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.

VI. Suggested Reading

- Atkinson ME and Dickson DCM. 2000. *An Introduction to Actuarial Studies*. Elgar Publ.
- Bedford T and Cooke R. 2001. *Probabilistic Risk Analysis*. Cambridge.
- Booth PM, Chadburn RG, Cooper DR, Haberman, S and James DE. 1999. *Modern Actuarial Theory and Practice*. Chapman & Hall.
- Borowiak Dale S. 2003. *Financial and Actuarial Statistics: An Introduction*. Marcel Dekker.
- Bowers NL, Gerber HU, Hickman JC, Jones DA and 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 Monographs)
- Daykin CD, Pentikainen T and Pesonen M. 1994. *Practical Risk Theory for Actuaries*. Chapman & Hall.
- Klugman SA, Panjer HH, Willmotand GE and Venter GG. 1998. *Loss Models: From data to Decisions*. John Wiley.
- Medina PK and 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 and 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.



- I. Course Title** : **Bioinformatics**
II. Course Code : **STAT 555**
III. Credit Hours : **2+0**

IV. Aim of the course

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.

V. 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/ RNAseq experiments.

VI. Suggested Reading

- Baldi P. and Brunak S. 2001. *Bioinformatics: The Machine Learning Approach*. 2nd Ed. (Adaptive Computation and Machine Learning). MIT Press.
- Baxevanis A.D. and Francis B.F. (Eds.). 2004. *Bioinformatics: A Practical Guide to the*



- Analysis of Genes and Proteins*. John Wiley.
- Bergeron B.P. 2002. *Bioinformatics Computing*. Prentice Hall.
 - Duda R.O, Hart P.E and Stork D.G. 1999. *Pattern Classification*. John Wiley.
 - Ewens W.J and Grant G.R. 2001. *Statistical Methods in Bioinformatics: An Introduction (Statistics for Biology and Health)*. Springer.
 - 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 and Livesy F. (Eds.). 2000. *Functional Genomics: A Practical Approach (The Practical Approach Series, 235)*. Oxford Univ. Press.
 - Jones N.C. and Pevzner P.A. 2004. *An Introduction to Bioinformatics Algorithms*. MIT Press.
 - Koski T and Koskinen T. 2001. *Hidden Markov Models for Bioinformatics*. Kluwer.
 - Krane D.E. and Raymer M.L. 2002. *Fundamental Concepts of Bio-informatics*. Benjamin / Cummings.
 - Krawetz S.A and Womble D.D. 2003. *Introduction to Bioinformatics: A Theoretical and Practical Approach*. Humana Press.
 - Lesk A.M. 2002. *Introduction to Bio-informatics*. Oxford Univ. Press.
 - Percus J.K. 2001. *Mathematics of Genome Analysis*. Cambridge Univ. Press.
 - Sorensen D and Gianola D. 2002. *Likelihood, Bayesian and MCMC Methods in Genetics*. Springer.
 - Tisdall J.D. 2001. *Mastering Perl for Bioinformatics*. O'Reilly & Associates.
 - Wang J.T.L., Zaki M.J., Toivonen H.T.T. and Shasha D. 2004. *Data Mining in Bioinformatics*. Springer.
 - Wu C.H. and McLarty J.W. 2000. *Neural Networks and Genome Informatics*. Elsevier.
 - Wunschiers R. 2004. *Computational Biology Unix/Linux, Data Processing and Programming*. Springer.

- I. Course Title : Econometrics**
II. Course Code : STAT 556
III. Credit Hours : 2+0

IV. Aim of the course

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.

V. 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.

Unit IV

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

Unit V

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

VI. Suggested Reading

- Croxton F.E. and Cowden D.J. 1979. *Applied General Statistics*. Prentice Hall of India.
- James H.S. and Mark W.W. 2017. *Introduction to Econometrics*, 3rd Ed. John Wiley
- Johnston J. 1984. *Econometric Methods*. McGraw Hill.
- Judge G.C., Hill R.C., Griffiths W.E., Lutkepohl H and Lee T.C. 1988. *Introduction to the Theory and Practice of Econometrics*. 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 G.S. 2001. *Introduction to Econometrics*. 3rd Ed. John Wiley.
- Pindyck R.S. and Rubinfeld D.L. 1998. *Econometric Models and Economic Forecasts*. 4th Ed. McGraw Hill.
- Verbeek M. 2008. *A Guide to Modern Econometrics*. 3rd Ed. John Wiley.

I. Course Title : Mathematics-II

II. Course Code : STAT 561

III. Credit Hours : 2+0

IV. Aim of the course

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.

V. 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, Gramian 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.

VI. Suggested Reading

- 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.

I. Course Title : Statistical Inference

II. Course Code : STAT 562

III. Credit Hours : 2+1

IV. Aim of the course

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.

V. 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 their properties. 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.

VI. Practical

- Methods of estimation - Maximum Likelihood, Minimum c^2 and Moments;
- Confidence Interval Estimation;
- MP and UMP tests;
- Large Sample tests;
- Non-parametric tests, Sequential Probability Ratio Test;
- Decision functions.

VII. Suggested Reading

- Box G.E.P. and Tiao G.C. 1992. *Bayesian Inference in Statistical Analysis*. John Wiley.
- Casela G and Berger R.L. 2001. *Statistical Inference*. Duxbury Thompson Learning.
- Christensen R. 1990. *Log Linear Models*. Springer.
- Conover W.J. 1980. *Practical Nonparametric Statistics*. John Wiley.
- Dudewicz EJ and Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.
- Gibbons J.D. 1985. *Non Parametric Statistical Inference*. 2nd Ed. Marcel Dekker.
- Kiefer J.C. 1987. *Introduction to Statistical Inference*. Springer.
- Lehmann EL. 1986. *Testing Statistical Hypotheses*. John Wiley.
- Lehmann EL. 1986. *Theory of Point Estimation*. John Wiley.
- Randles R.H and Wolfe D.S. 1979. *Introduction to the Theory of Nonparametric Statistics*. John Wiley.
- Rao C.R. 2009. *Linear Statistical Inference and Its Applications*, 3rd Ed. John Wiley.
- Rohatgi V.K. and Saleh A.K. Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.
- Rohtagi V.K. 1984. *Statistical Inference*. John Wiley
- Sidney S and Castellan N.J. 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



- I. Course Title** : Design of Experiments
II. Course Code : STAT 563
III. Credit Hours : 2+1

IV. Aim of the course

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.

V. Theory

Unit I

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

Unit II

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

Unit V

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

Unit VI

Cross-over designs. Missing plot technique; Split plot and Strip plot design; Groups of experiments. Sampling in field experiments.

VI. 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.

VII. Suggested Reading

- Chakrabarti M.C. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publ.House.
- Cochran W.G. and Cox D.R. 1957. *Experimental Designs*. 2nd Ed. John Wiley.
- Dean A.M. and Voss D. 1999. *Design and Analysis of Experiments*. Springer.
- Dey A and Mukerjee R. 1999. *Fractional Factorial Plans*. John Wiley.
- Dey A 1986. *Theory of Block Designs*. Wiley Eastern. Hall M Jr. 1986. *Combinatorial Theory*. John Wiley.
- John J.A. and Quenouille M.H. 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 A.M. 1983. *A Course in Linear Models*. Marcel Dekker.
- Montgomery D.C. 2013. *Design and Analysis of Experiments*. John Wiley & Sons
- Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*. John Wiley.
- Searle S.R. 2006. *Linear Models*. John Wiley.
- Street A.P. and Street D.J. 1987. *Combinatorics of Experimental Designs*. Oxford Science Publ.
- Design Resources Server. *Indian Agricultural Statistics Research Institute (ICAR), New Delhi-110 012, India*. Hyperlink "<http://www.iasri.res.in/design>" www.drs.icar.gov.in.

- I. Course Title : Sampling Techniques**
II. Course Code : STAT 564
III. Credit Hours : 2+1
IV. Aim of the course

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

V. 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.

VI. Practical

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

VII. Suggested Reading

- Cassel C.M., Sarndal C.E. and Wretman J.H. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.
- Chaudhari A and Stenger H. 2005. *Survey Sampling Theory and Methods*. 2nd Ed. Chapman & Hall.
- Chaudhari A and Voss J.W.E. 1988. *Unified Theory and Strategies of Survey Sampling*. North Holland.
- Cochran W.G. 1977. *Sampling Techniques*. John Wiley.
- Hedayat A.S. and Sinha B.K. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.
- Kish L. 1965. *Survey Sampling*. John Wiley.
- Mukhopadhyay, P. 2008.
- *Theory and Methods of Survey Sampling*, John Wiley & Sons
- Murthy M.N. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Society, Calcutta.
- Sukhatme P.V., Sukhatme B.V., Sukhatme S and Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Thompson SK. 2000. *Sampling*. John Wiley.
- Kochran WG. 2007. *Sampling Techniques*. A John Wiley & Sons Publication

I. Course Title : Statistical Genetics

II. Course Code : STAT 565

III. Credit Hours : 2+1

IV. Aim of the course

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

V. Theory**Unit I**

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

**Unit II**

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

Unit III

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

Unit IV

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

Unit VI

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

VI. Practical

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

VII. Suggested Reading

- Agarwal BL and Agarwal SP. 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 and Cannings C. 2001. *Hand Book of Statistical Genetics*. John Wiley.
- Crow JF and Kimura M. 1970. *An Introduction of Population Genetics Theory*. Harper and Row.
- Dahlberg G. 1948. *Mathematical Methods for Population Genetics*. Inter Science Publ.
- East EM and Jones DF. 1919. *Inbreeding and Outbreeding*.
- Lippincott JB & Co. 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.
- K & Jinks JL. 1977. *Introduction to Biometrical Genetics*. Chapman & Hall.
- Mather K and 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.

- I. Course Title : Statistical Quality Control**
II. Course Code : STAT 566
III. Credit Hours : 2+0

IV. Aim of the course

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.

V. 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.

VI. Suggested Reading

- Cowden D.J. 1957. *Statistical Methods in Quality Control*. Prentice Hall of India.
- Dodge H.F. and Romig H.G. 1959. *Sampling Inspection Tables*. John Wiley.
- Duncan A.J. 1986. *Quality Control and Industrial Statistics*. 5th Ed. Irwin Book Co.
- Grant E.L. and Leavenworth R.S. 1996. *Statistical Quality Control*. 7th Ed. McGraw Hill.
- Montgomery D.C. 2008. *Introduction to Statistical Quality Control*. 6th Ed. John Wiley.
- Wetherhil G.B. 1977. *Sampling Inspection and Quality Control*. Halsted Press.



- I. Course Title : **Optimization Techniques**
 II. Course Code : **STAT 567**
 III. Credit Hours : **1+1**

IV. Aim of the course

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.

V. 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, Powell'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,

VI. 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.

VII. Suggested Reading

- Antunes C.H., Alves, M.J., 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, K.L. Zhang Y. 2016. *Optimization and Control Techniques and Applications* (Springer Proceedings in Mathematics & Statistics)
- Zeleny, M. 1974. *Linear Multi objective Programming*. Springer.

- I. Course Title** : **Multivariate Analysis**
II. Course Code : **STAT 571**
III. Credit Hours : **2+1**

IV. Aim of the course

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.

V. 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 Mahalanobis D^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.

VI. 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.



VII. Suggested Reading

- 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 and 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 and Khatri CG. 1979. *An Introduction to Multivariate Statistics*. North Holland.

I. Course Title : Regression Analysis

II. Course Code : STAT 572

III. Credit Hours : 1+1

IV. Aim of the course

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.

V. 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.

VI. Practical

- Multiple regression fitting with three and four independent variables;
- Estimation of residuals, their applications in outlier detection, distribution of residuals;



- Test of homoscedasticity, and normality, Box-Cox transformation;
- Restricted estimation of parameters in the model, hypothesis testing, Step wise regression analysis;
- Least median of squares norm, Orthogonal polynomial fitting.

VII. Suggested Reading

- Barnett V and Lewis T. 1984. *Outliers in Statistical Data*. John Wiley.
- Belsley DA, Kuh E and Welsch RE. 2004. *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity*. John Wiley.
- Chatterjee S and Hadi AS. 2013. *Regression Analysis by Example*. A John Wiley & sons Publication.
- Draper NR and Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- McCullagh P and Nelder JA. 1999. *Generalized Linear Models*. 2nd Ed. Chapman & Hall.
- Montgomery DC, Peck EA and 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.

I. Course Title : Statistical Computing

II. Course Code : STAT 573

III. Credit Hours : 1+1

IV. Aim of the course

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.

V. 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

VI. 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.

VII. Suggested Reading

- Agresti A. 2013. *Categorical Data Analysis*. 3rd Ed. John Wiley.
- Everitt BS and 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 and Mori Y. 2012. *Handbook of Computational Statistics - Concepts and Methods*. 2nd Ed. Springer.
- Han J and Kamber M. 2000. *Data Mining: Concepts and Techniques*. Morgan.
- Hastie T, Tibshirani R and 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 and Joiner BL. 1994. *MINITAB Handbook*. 3rd Ed. Duxbury Press.
- Simonoff JS. 1996. *Smoothing Methods in Statistics*. Springer.
- Singh, AK. 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 and 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.

I. Course Title : Time Series Analysis

II. Course Code : STAT 574

III. Credit Hours : 1+1

IV. Aim of the course

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.



V. 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.

VI. 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.

VII. Suggested Reading

- Box GEP, Jenkins GM and Reinsel GC. 2007. *Time Series Analysis: Forecasting and Control*. 3rd Ed. Pearson Edu.
- Brockwell PJ and Davis RA. 2002. *Introduction to Time Series and Forecasting*. 2nd Ed. Springer.
- Chatterjee S, Hadi A and Price B. 1999. *Regression Analysis by Examples*. John Wiley.
- Draper NR and 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 and Lee TC. 1988. *Introduction to the Theory and Practice of Econometrics*. 2nd Ed. John Wiley.
- Montgomery DC and Johnson LA. 1976. *Forecasting and Time Series Analysis*. McGraw Hill.
- Montgomery DC, Jennings CA and Kulahci M. 2015. *Introduction to Time Series Analysis and Forecasting*, Wiley Series in Probability and Statistics
- Shumway RH and Stoffer DS. 2006. *Time Series Analysis and its Applications: With R Examples*. 2nd Ed. Springer.

- I. Course Title** : Demography
II. Course Code : STAT 575
III. Credit Hours : 2+0
IV. Aim of the course

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 in bioassays.



V. Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

VI. Suggested Reading

- 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 and Pugh TF. 1970. *Epidemiology- Principles and Methods*. Little Brown, Boston.
- Mann NR, Schafer RE and 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 and Guillot M. 2001. *Demography: Measuring and Modeling Population Processes*. Blackwell Publ.
- Rowland DT. 2004. *Demographic Methods and Concepts*. Oxford Press.
- Siegel JS and Swanson DA. 2004. *The Methods and Material of Demography*. 2nd Ed. Elsevier.
- Woolson FR. 1987. *Statistical Methods for the Analysis of Biomedical Data*. John Wiley.
- Yakovlev AY, Klebanov L and Gaile D. 2013. *Statistical Methods for Microarray Data Analysis: Methods and Protocols* (Methods in Molecular Biology)

- I. Course Title : Statistical Methods for Life Sciences
 II. Course Code : STAT 576
 III. Credit Hours : 2+0

IV. Aim of the course

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.



V. 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 structural models.

Unit IV

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

Unit V

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

VI. Suggested Reading

- 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 D.R. and Oakes D. 1984. *Analysis of Survival Data*. Chapman & Hall.
- Hosmer DW Jr. and Lemeshow S. 1999. *Applied Survival Analysis: Regression Modeling or Time to Event*. John Wiley.
- Klein J.P. and Moeschberger M.L. 2003. *Survival Analysis: Techniques for Censored and Truncated Data*. Springer.
- Kleinbaum D.G. and Klein M. 2005. *Survival Analysis. A Self Learning Text*. Springer.
- Kleinbaum D.G. and Klein M. 2005. *Logistic Regression*. 2nd Ed. Springer.
- Lee ET. 1992. *Statistical Methods for Survival Data Analysis*.
- John Wiley and Miller RG. 1981. *Survival Analysis*. John Wiley.
- Therneau T.M. and Grambsch P.M. 2000. *Modeling Survival Data: Extending the Cox Model*. Springer.

I. Course Title : Statistical Ecology

II. Course Code : STAT 577

III. Credit Hours : 2+0

IV. Aim of the course

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.

V. 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.

VI. Suggested Reading

- Gotelli N.J. and Ellison A.M. 2004. *A Primer of Ecological Statistics*
- Pielou E.C. 1970. *An introduction to Mathematical Ecology*. John Wiley.
- Reynolds J.F. and Ludwig J.A. 1988. *Statistical Ecology: A Primer on Methods and Computing*. JohnWiley.
- Young L.J., Young J.H. and Young J. 1998. *Statistical Ecology: A Population Perspective*. Kluwer.