DEPARTMENT OF AGRICULTURAL STATISTICS

M. Sc. Programme

Course No.	Course Title	Credits
1st Semester		
STAT -501	Mathematical Methods for Applied Sciences	3+0
STAT - 502	Mathematical Methods- I	3+0
STAT - 503	Probability Theory	2+0
STAT - 504	Statistical Methods	2+1
STAT - 505	Statistical Inference	2+1
STAT - 511	Statistical methods with Design of Experiments for Applied Sciences	2+1
STAT - 512	Applied Regression Analysis	2+1
STAT - 513	Computer Fundamentals and Programming	2+1
STAT - 514	Statistical Methods for Crop Improvement	2+1
2nd Semester		
STAT - 551	Mathematical Methods- II	2+0
STAT - 552	Multivariate Analysis	2+1
STAT - 553	Design of Experiments	2+1
STAT - 554	Sampling Techniques	2+1
STAT - 561	Statistical Methods Applied to Biological Research workers	2+1
STAT - 562	Elementary Statistical Methods and Sampling techniques for Horticultural Research	2+1
STAT - 563	Statistical Methods Applied to Agricultural Research workers	2+1
3rd Semester		
STAT - 601	Statistical Genetics	2+1
STAT - 602	Regression Analysis & Forecasting	1+1
STAT - 603	Statistical Computing	1+1
STAT - 604	Time Series Analysis	1+1
STAT - 605	Actuarial Statistics	2+0
STAT - 606	Bioinformatics	2+0
STAT - 607	Econometrics	2+0
STAT - 608	Factorial Experiments	1+1
STAT – 649	Seminar – I	1+0

4th Semester		
STAT - 651	Statistical Quality Control	2+0
STAT - 652	Optimization Techniques	1+1
STAT - 653	Demography	2+0
STAT - 654	Statistical Methods for Life Sciences	2+0
STAT - 655	Statistical Ecology	2+0
STAT - 699	Seminar II	1+0
STAT - 700	Master's Research	0+20

1. STAT-502 and STAT- 551 are supporting courses. These are compulsory for all the students of Agricultural Statistics.
2. STAT- 503 to STAT- 505 and STAT- 552 to STAT- 554 are core courses to be taken by all the students of Agricultural Statistics.

Course Contents:

M. Sc. Programme:

STAT- 501 Mathematical Methods for Applied Sciences 3+0

Theory

Variables and functions; limit and continuity. Specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, function of a function, derivative of higher order, partial derivatives. Application of derivatives in agricultural research; determination of points of inflexion, maxima and minima in optimization, etc.

Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral; Applications of integration in agricultural research with special reference to economics and genetics, engineering, etc.

Vectors and vector spaces, Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; Eigen values and eigen vectors. Determinants - evaluation and properties of determinants, application of determinants and matrices in solution of equation for economic analysis.

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

STAT- 502: Mathematical Methods- I 3+0

Theory

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.

Calculus: Limit and continuity, differentiation of functions, successive differentiation, partial differentiation, mean value theorems, Taylor and Maclaurin's

series. Application of derivatives, L'hospital's rule. Integration of rational, irrational and trigonometric functions. Application of integration.

Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient. Numerical Analysis: Simple interpolation, Divided differences, Numerical differentiation and integration.

STAT- 503 Probability Theory 2+0

Theory

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

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.

Conditional expectation and conditional variance. Characteristic function and its properties. Chebyshev, Markov, Cauchy-Schwartz, Jenson, Liapounov, Holder's and Minkowsky's inequalities. Borel –Cantelli lemma and Borel 0-1 law.

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

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

STAT- 504 Statistical Methods 2+1

Theory

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.

Concepts of compound, truncated and mixture distributions (definitions and examples). Pearsonian curves and its various types. Sampling distributions of sample

mean and sample variance from Normal population, central and non–central chi-Square, *t* and *F* distributions, their properties and inter relationships.

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.

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

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

STAT- 505 Statistical Inference 2+1

Theory

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

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

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

Notions of sequential vs fixed sample size techniques. Wald's SPRT for testing simple null hypothesis vs simple alternative. Termination property 25 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.

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

STAT- 511 Statistical Methods with Design of Experiments for Applied Sciences 2+1

Classification, tabulation and graphical representation of data. Descriptive statistics. Exploratory data analysis; Theory of probability. Random variable and mathematical expectation. Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution 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. Large sample theory.

Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination.

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control. Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

Factorial experiments, (symmetrical as well as asymmetrical). Confounding in symmetrical factorial experiments, Factorial experiments with control treatment. Split plot and strip plot designs; Analysis of missing plot techniques in randomized block and Latin square designs;

STAT- 512 Applied Regression Analysis 2+1

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

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

Examining the multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation; regression approach applied to analysis of variance in one way classification.

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

STAT- 513 Computer Fundamentals and Programming 2+1

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

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

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

Sequencing, alteration and iteration; Arrays, string processing. Sub-programs, recursion, pointers and files. Program correctness; Debugging and testing of programs.

STAT 514 Statistical Methods for Crop Improvement 2+1

Central tendency and Dispersion, Probability definition, Properties, Mathematical Expectation, Probability Distribution: Discrete and Continuous.Correlation and Regression: Simple and Multiple Regression.

Sampling techniques. Sample survey vs complete survey, probability sampling, Simple random sampling, Estimation of population proportion, Stratified random sampling, Non-sampling errors – sources and classification.

Bioassay, Basic Concepts. Parametric Tests of Hypothesis, Small and Large Sample tests. Test of significance: Null hypothesis, error of type-I and II. Exact small test: Normal, t, Chi- Square and F.

Design of Experiment: CRD, RCBD, LSD, Factorial Experiments (Symmetrical and Asymmetrical); Split Plot and Strip Plot,

Estimation of Linkage and Genetic Parameters. Concepts of general and specific combining ability. Diallel and partial diallel crosses - construction and analysis.

STAT- 551 Mathematical Methods- II 2+0

Theory

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

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

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.

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

STAT- 552 Multivariate Analysis 2+1

Theory

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.

Wishart distribution and its simple properties. Hotelling's T2 and Mahalanobis D2 statistics. Null distribution of Hotelling's T2. Rao's U statistics and its distribution. Wilks' λ criterion and statement of its properties. Concepts of discriminant analysis,

computation of linear discriminant function, classification between k (≥ 2) multivariate normal populations based on LDF and Mahalanobis D2.

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

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

STAT- 553 Design of Experiments 2+1

Theory

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.

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

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

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

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

STAT- 554 Sampling Techniques 2+1

Theory

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

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

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

Sampling with varying probabilities with and without replacement, PPS sampling, 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, PPS systematic sampling, Multistage sampling with unequal probabilities, Self weighting design PPS sampling.

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

STAT 561 Statistical Methods Applied to Biological Research Workers 2+1

Probability: Elementary concept of Probability. Addition theorem. Conditional probability and Multiplication theorem. Elementary Statistical Methods: Population and its Parameters. Sample and its Statistics. Frequencydistribution. Graphical representation. Moments. Probability distributions: Binomial, Poisson and Normal. Simple correlation and regression.

Calculation of AUDCC, Formation of linear and non linear growth model like logistic, gompartz etc.

Analysis of time data using parametric and non parametric methods.

Test of significance: Null hypothesis, error of type-I and II. Exact small test: Normal, t, Chi- Square and F. Analysis of variance: One-way classification and two-way classification (Orthogonal classification). Principles of design of experiments. Uniformity trials: Fertility contour map. Fundamental design: CRD, RCBD, LSD, Split Plot and Strip Plot. Direct assay; Investigations of dose response relationship as Probit analysis.

STAT- 562: Elementary Statistical Methods and Sampling Techniques for Horticultural Research 2+1

Classification, tabulation and graphical representation of data. Descriptive statistics. Exploratory data analysis; Theory of probability. Random variable and mathematical expectation. Discrete and continuous probability distributions: Binomial, Poisson, Normal distribution and their applications. Tests of significance based on Normal, chi-square, *t* and *F* distributions. Large sample theory.

Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients.

Sampling techniques. Sample survey vs complete survey, probability sampling, Simple random sampling, Estimation of population proportion, Stratified random sampling, Number of strata and optimum points of stratification. Non-sampling errors – sources and classification.

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control. Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design. Factorial experiments, (symmetrical as well as asymmetrical).Confounding in symmetrical factorial experiments, Factorial experiments with control treatment. Split plot and strip plot designs; Analysis of missing plot techniques in randomized block and Latin square designs;

STAT – 563 Statistical Methods Applied to Agricultural Research workers:

Central tendency and Dispersion, Probability definition, Properties, Mathematical Expectation, Probability Distribution: Discrete and Continuous.

Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients.

Sampling techniques. Sample survey vs complete survey, probability sampling, Simple random sampling, Estimation of population proportion, Stratified random sampling, Number of strata and optimum points of stratification. Non-sampling errors – sources and classification.

Bioassay: Basic Concepts. Parametric Tests of Hypothesis, Small and Large Sample tests, Design of Experiment: CRD, RCBD, LSD, Split Plot and Strip Plot, Application of Multivariate Statistics for Soil Quality Indexing.

STAT- 601: Statistical Genetics 2+1

Theory

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

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.

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.

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

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

Restricted selection index. 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.

STAT- 602 Regression Analysis & Forecasting 1+1

Theory

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

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

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

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

Introduction to non-linear models, nonlinear estimation: Least squares for nonlinear models., Forecasting with a single equation linear regression model; Point prediction and interval prediction; Evaluation of the forecasting performance of an estimated model; Prediction, Realisation, Theil's inequality coefficient, Jame's quotient.

STAT- 603 Statistical Computing 1+1

Theory

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

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

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

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

STAT- 604: Time Series Analysis 1+1

Theory

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

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

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

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.

STAT- 605 Actuarial Statistics 2+0

Theory

Insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

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

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.

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

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

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.

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.

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.

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.

STAT- 606 Bioinformatics 2+0

Theory

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.

Computing techniques: OS and Programming Languages – *Linux, perl*, *bioperl*, *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.

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;

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, Hidden Markov models. Computational analysis of protein sequence, structure and function; Design and Analysis of microarray experiments.

STAT- 607 Econometrics 2+0

Theory

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.

Heteroscedasticity, Auto-correlation, Durbin Watson test, Multicollinearity. 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.

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.

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

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.

STAT- 608 Factorial Experiments 1+1

Theory

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

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

STAT- 651: Statistical Quality Control 2+0

Theory

Introduction to Statistical Quality Control; Control Charts for Variables – Mean, Standard deviation and Range charts; Statistical basis; Rational subgroups.

Control charts for attributes- 'np', 'p' and 'c' charts.

Fundamental concepts of acceptance, sampling plans, single, double and sequential sampling plans for attributes inspection.

Sampling inspection tables for selection of single and double sampling plans.

STAT- 652: Optimization Techniques 1+1

Theory

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

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

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

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

STAT- 653 Demography 2+0

Theory

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

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

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.

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.

STAT- 654 Statistical Methods for Life Sciences 2+0

Theory

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

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 nonparametric 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).

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.

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.

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

STAT- 655 Statistical Ecology 2+0

Theory

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

Species-abundance relations: Distribution models, Diversity indices; Species affinity: Niche-overlap indices, interspecific association, interspecific covariation.

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

Community interpretation: Classification Interpretation and Ordination Interpretation.