कृषि सांख्यिकी

NEWSYLLABUSASNATIONALEDUCATIONPOLICY (NEP)2020

(NEW ANDRESTRUCTURED)

POSTGRADUATE & Ph.D.CURRICULA&SYLLABUS

Co-ordinator/Ph.D 23/05/22

M.Sc.& Ph.D. in Agricultural Statistics

SemesterSystemasper ICARVthDeansCommitteeReport

DEPARTMENT

OF

AGRICULTURAL STATISTICS

MAHARAJA SUHEL DEV STATE UNIVERSITY, AZAMGARH, UTTAR PRADESH

Submittedby:

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MAHARAJA SUHEL DEV STATE UNIVERSITY, AZAMGARH, UTTAR PRADESH

Contents

OrganizationofCourseContentsandCreditRequirements

OrganizationofCourseContentsand Credit Requirements

- The current nomenclature of M.Sc. and Ph.D. programme has been finalized as M.Sc. (Ag.) Statistics and Ph.D. (Agricultural Statistics).
- Allcoursesaredividedintotwoseries:500-seriescoursespertaintoMaster'slevel, and600-seriestoDoctorallevel.APh.D.studentmusttake500-seriescoursesifnot studied during Master's programme.
- Master's programmehave a minimum 70 Credit Hours (consisting of 20 from core course, 8 from minorcourse, 6 from supporting course, 5 from common course, 1 credit seminar and 30 research credit hours).
- Similarly, for Ph.D. programme,the members suggested a total of 100 credit hours (including 12 from core course, 6 from minorcourse, 5 from supporting course, 2 credit seminars and 75 credit for research work).
- Maximumofcreditloadof20credithoursand18credithourspersemesterfor M.Sc. and Ph.D. programmes respectively.
- Credit seminar for Master's level is designated by Code no. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively.
- Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively.

CourseContents

Thecontentsofeachcoursehavebeenorganizedinto:

- Objective–toelucidatethebasicpurpose.
- Theoryunits–tofacilitateuniformcoverageofsyllabusforpapersetting.
- Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources-forquickupdateonspecifictopics/eventspertainingtothe subject.
- Broadresearchtopicsprovidedattheendwouldfacilitatetheadvisorsforappropriate research directions to the Students.

MinimumCreditRequirements

		Masters'Programme	DoctoralProgramme
i.	Coursework		
	Majorcourses	20	12
	Minorcourses	08	06
	Supportingcourses	06	05
	Commoncourses	05	–
	Seminar	01	02
ii.	**ThesisResearch**	30	75
	Total	70	100

Major courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken given *mark.

Minorcourses:Fromthesubjectscloselyrelatedtoastudent`smajorsubject.

Supporting courses: The subject not related to the major subject. It could be any subjectconsideredrelevantforstudent'sresearchwork(suchasStatisticalMethods,Design of Experiments, etc.) or necessary for building his/her overall competence.

Common Courses: The following courses(one credit each) will be offered to all students undergoing Master's degree programme.

1. LibraryandInformationServices
2. Technical Writing and CommunicationsSkills
3. IntellectualPropertyanditsmanagementinAgriculture
4. BasicConceptsinLaboratoryTechniques
5. AgriculturalResearch,ResearchEthicsandRuralDevelopmentProgrammes

Some of these courses are already in the form of e-courses/ MOOCs. The students maybe allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approvalof the HoD/ BoS.

CourseTitlewithCreditLoad

M.Sc.inAgriculturalStatistics

CourseCode	CourseTitle	CreditHours	Semester
*STAT552	ProbabilityTheory	2+0	I
*STAT553	StatisticalMethods	2+1	I
*STAT562	StatisticalInference	2+1	II
*STAT563	DesignofExperiments	2+1	II
*STAT564	SamplingTechniques	2+1	II
*STAT565	StatisticalGenetics	2+1	II
*STAT571	MultivariateAnalysis	2+1	III
*STAT572	RegressionAnalysis	1+1	III
*STAT573	StatisticalComputing	1+1	III
STAT591	Seminar	0+1	III
STAT599	Research	0+30	II-IV
STAT551	Mathematics-I	3+0	I
STAT554	ActuarialStatistics	2+0	I
STAT555	Bioinformatics	2+0	I
STAT556	Econometrics	2+0	I
STAT561	Mathematics-II	2+0	II
STAT566	StatisticalQualityControl	2+0	II
STAT567	OptimizationTechniques	1+1	II
STAT574	TimeSeriesAnalysis	1+1	III
STAT575	Demography	2+0	III
STAT576	StatisticalMethodsforLifeSciences	2+0	III
STAT577	StatisticalEcology	2+0	III
	SupportingCourses		
STAT501	MathematicsforAppliedSciences	2+0	I
STAT502	StatisticalMethodsforAppliedSciences	3+1	I
STAT511	ExperimentalDesigns	2+1	II
STAT512	BasicSamplingTechniques	2+1	II
STAT521	AppliedRegressionAnalysis	2+1	III
STAT522	DataAnalysisUsingStatisticalPackages	2+1	III

*CoreCourses

CourseContents
M.Sc.inAgriculturalStatistics

I. CourseTitle :**MathematicsforAppliedSciences**

II. CourseCode :**STAT501**

III. CreditHours :**2+0**

IV. Aimofthecourse

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

V. Theory

UnitI

Settheory-setoperations,finiteandinfinitesets,operationsofset,function.

UnitII

Vectorsandvectorspaces,Matricesnotationsandoperations,lawsofmatrixalgebra; transpose and inverse of matrix, Eigen values and Eigen vectors. Determinants - evaluationandpropertiesofdeterminants,SolutionsofLinearEquations.

UnitIII

Variables and functions, limits and continuity of specific functions. Differentiation: theoremsofdifferentiation,differentiationoflogarithmic,trigonometric,exponential andinversefunctions,Differentiationoffunctionofafunction,derivativesofhigher order, partial derivatives. Application of derivatives, determination of points of inflexion, maxima and minima.

UnitIV

Integration,methodsofintegration,reductionformulae,definiteandindefinite integral,ApplicationsofintegrationinAgriculture,DifferentialEquations.

VI. SuggestedReading

- HohnFE.2013.*ElementaryMatrixAlgebra*,3rdEd.,KindleEdition
- HarvilleD.A.1997.*MatrixAlgebrafromaStatistician'sPerspective*.Springer.
- HohnF.E.1973.*ElementaryMatrixAlgebra*.Macmillan.
- Searle S.R. 1982. *Matrix Algebra Useful for Statistics*. John Wiley. Stewart J. 2007. *Calculus*. Thompson.
- ThomasG.B.Jr. andFinney R.L.1996.*Calculus*.9thEd.Pearson Edu.

I. CourseTitle :**StatisticalMethodsforAppliedSciences**

II. CourseCode :**STAT502**

III. CreditHours :**3+1**

IV. Aimofthecourse

ThiscourseismeantforstudentswhodonothavesufficientbackgroundofStatistical 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,regressionandmultivariateanalyticaltechniques.

V. Theory

UnitI

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

UnitII

Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial,Normaldistribution,BetaandGammadistributionsandtheirapplications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significancebasedonNormal,chi-square,$t$and$F$distributions.

UnitIII

Introduction to theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linearregressionmodel,testofsignificanceofcorrelationcoefficientandregression coefficients,Coefficientofdetermination,Fittingofquadraticmodels.

UnitIV

Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomnessofasequence.Mediantest.

UnitV

IntroductiontoANOVA:OnewayandTwoWay,IntroductiontoSamplingTechniques,Introducti ontoMultivariateAnalysis,TransformationofData.

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-parametrictests.ANOVA:Oneway,TwoWay,SRS.

VII. SuggestedReading

- GoonA.M,GuptaM.KandDasguptaB.1977.*AnOutlineofStatisticalTheory*.Vol.I.The World Press.
- Goon A.M, Gupta M.K. and Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.
- HoelP.G.1971.*IntroductiontoMathematicalStatistics*.John Wiley.
- HoggR.VandCraigT.T.1978.*IntroductiontoMathematicalStatistics*.Macmillan.
- MorrisonD.F.1976.*MultivariateStatisticalMethods*.McGrawHill.
- HoggRV,McKeanJW,CraigAT.2012.*IntroductiontoMathematicalStatistics*7thEdition.
- SiegelS,JohanN&CasellanJr.1956.*Non-parametricTestsforBehaviorSciences*.John Wiley.
- AndersonTW.2009.*AnIntroductiontoMultivariateStatisticalAnalysis*,3rdEd.JohnWiley
- http://freestatistics.altervista.org/en/learning.php.
- http://www.statsoft.com/textbook/stathome.html.

I. CourseTitle :ExperimentalDesigns
II. CourseCode :STAT511
III. CreditHours :2+1

IV. Aimofthecourse

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 DesignofExperimentssoastoenablethemtounderstandtheconceptsinvolved inplanning,designingtheirexperimentsandanalysisofexperimentaldata.

V. Theory

UnitI

Needfordesigningofexperiments,characteristicsofagooddesign.Basicprinciples ofdesigns-randomization,replicationandlocalcontrol.

UnitII

Uniformitytrials,sizeandshapeofplotsandblocks,Analysisofvariance,Completelyrando mizeddesign,randomizedblockdesignandLatinsquaredesign.

UnitIII

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioningofdegreesoffreedom.Conceptofconfounding.

UnitIV

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.Responsesurfaces.Combinedanalysis.

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,
- Analysiswith missing data,
- Splitplotandstripplotdesigns.

VII. SuggestedReading

- CochranWGandCoxGM.1957.*ExperimentalDesigns*.2nd Ed.JohnWiley.
- DeanAMandVossD.1999.*DesignandAnalysisofExperiments*.Springer.
- MontgomeryDC.2012.*DesignandAnalysisofExperiments*,8th Ed.JohnWiley.
- FedererWT.1985.*ExperimentalDesigns*.MacMillan.
- FisherRA.1953.*DesignandAnalysisofExperiments*.Oliver&Boyd.
- Nigam AK and Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.
- PearceSC.1983.*TheAgriculturalFieldExperiment:AStatisticalExaminationofTheory andPractice*.JohnWiley.
- www.drs.icar.gov.in.

I. CourseTitle **:BasicSamplingTechniques**

II. CourseCode **:STAT512**

III. CreditHours **:2+1**

IV. Aimofthecourse

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 presentationof results. This course would be especially important to the students of social sciences.

V. Theory

UnitI

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

UnitII

Simple random sampling with and without replacement, sampling for proportion, determinationofsamplesize,inversesampling,Stratifiedsampling.

UnitIII

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

UnitIV

Use of auxiliary information at estimation, Ratio product and regression estimators. DoubleSampling,samplingandnon-samplingerrors.

VI. Practical

- Randomsampling~useofrandomnumbertables,conceptsofunbiasedness, variance, etc.;
- Simplerandomsampling,determinationofsamplesize,inversesampling,stratified sampling, cluster sampling and systematic sampling;
- Estimationusingratioandregressionestimators;
- Estimationusingmultistagedesign,doublesampling.

VII. SuggestedReading

- CochranWG.1977.*SamplingTechniques*.JohnWiley.
- Murthy MN. 1977.*Sampling Theoryand Methods*. 2nd Ed. Statistical Publ.Soc., Calcutta.
- SinghD,SinghPandKumarP.1982.*HandbookonSamplingMethods*.IASRI Publ.
- SukhatmePV,SukhatmeBV,SukhatmeSandAsokC.1984.*SamplingTheoryofSurveys withApplications*.IowaStateUniversityPressandIndianSocietyofAgriculturalStatistics, NewDelhi.
- CochranWG.2007.*SamplingTechniques*.3rd Edition.JohnWiley&SonsPublication

I. CourseTitle :AppliedRegressionAnalysis

II. CourseCode :STAT521

III. CreditHours :2+1

IV. Aimofthecourse

Thiscourseismeantforstudentsofalldisciplinesincludingagriculturalandanimal 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 handletheirdataforanalysisandinterpretation.

V. Theory

UnitI

Introduction to correlation analysis and its measures, Correlation from groupeddata, correlation, Rank correlation, Testing of population correlation coefficients; Multipleandpartialcorrelationcoefficientsandtheirtesting.

UnitII

Problem of correlated errors; Auto correlation; Heteroscedastic models, Durbin Watson Statistics;Removalofautocorrelationbytransformation;Analysisofcollineardata; Detection and correction of multi collinearity, Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial

regressions.

UnitIII

Diagnostic of multiple regression equation; Concept of weighted least squares; regressionequationongroupeddata;Variousmethodsofselectingthebest regressionequation.

UnitIV

Conceptofnonlinearregressionandfittingofquadratic,exponentialandpower curves;Economicandoptimaldose,Orthogonalpolynomial.

VI. Practical

- Correlationcoefficient,varioustypesofcorrelationcoefficients,partialandmultiple, testing of hypotheses;
- Multiplelinearregressionanalysis,partialregressioncoefficients,testingof hypotheses, residuals and their applications in outlier detection;
- Handlingofcorrelatederrors,multicollinearity;
- Fittingof quadratic,exponential and powercurves, fitting oforthogonalpolynomials.

VII. SuggestedReading

- KleinbaumDG,KupperLL,NizamA.2007.*AppliedRegressionAnalysisandOther Multivariable Methods* (Duxbury Applied) 4thEd.
- DraperNRandSmithH.1998.*AppliedRegressionAnalysis*.3rdEd.JohnWiley.
- EzekielM.1963.*MethodsofCorrelationandRegressionAnalysis*.JohnWiley.
- KoutsoyiannisA.1978.*TheoryofEconometrics*.MacMillan.
- Kutner MH, Nachtsheim CJ and Neter J. 2004. *Applied Linear Regression Models*. 4thEd. With Student CD. McGraw Hill.

I. CourseTitle :DataAnalysisUsingStatisticalPackages

II. CourseCode :STAT522

III. CreditHours :2+1

IV. Aimofthecourse

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 experienceintheanalysisoftheirresearchdata.Thiscourseisusefultoalldisciplines.

V. Theory

UnitI

Introductiontovariousstatisticalpackages:Excel,R,SAS,SPSS.DataPreparation; Descriptivestatistics;Graphicalrepresentationofdata,Exploratorydataanalysis.

UnitII

Testfornormality;Testingofhypothesisusingchi-square,*t*and*F*statisticsand Z-test.

UnitIII

DatapreparationforANOVAandANCOVA,FactorialExperiments,contrast analysis,multiplecomparisons,Analyzingcrossedandnestedclassifieddesigns.

UnitIV

Analysisofmixedmodels;Estimationofvariancecomponents;Correlationand regressionanalysis,Probit,LogitandTobitModels.

UnitV

Discriminant function; Factor analysis; Principal component analysis; Analysis of timeseriesdata,Fittingofnon-linearmodels;Neuralnetworks.

VI. Practical

- Useofsoftwarepackagesforsummarizationandtabulationofdata,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;
- DesignsforFactorialExperiments,fixedeffectmodels,randomeffectmodels,mixed effect models, estimation of variance components;
- Linearregression,Multipleregression,Regressionplots;
- Discriminant analysis - fitting of discriminant functions, identification of important variables;
- Factoranalysis.Principalcomponentanalysis-obtainingprincipalcomponent.

VII. SuggestedReading

- AndersonC.W.andLoynesR.M.1987.*TheTeachingofPracticalStatistics*.JohnWiley.
- AtkinsonA.C.1985.*PlotsTransformationsandRegression*.OxfordUniversityPress.
- ChambersJ.M.,ClevelandW.S.,KleinerBandTukeyP.A.1983.*GraphicalMethodsfor Data Analysis*. Wadsworth, Belmount, California.
- ChatfieldC.1983.*StatisticsforTechnology*.3rdEd.Chapman&Hall.ChatfieldC.1995. *ProblemSolving:AStatistician'sGuide*.Chapman&Hall.
- ClevelandW.S.1985.*TheElementsofGraphingData*.Wadsworth,Belmont,California.
- EhrenbergASC.1982.*APrimerinDataReduction*.JohnWiley.
- Erickson B.H. and Nosanchuk T.A. 1992. *Understanding Data*. 2ndEd. Open University Press, Milton Keynes.
- SnellE.J.andSimpsonHR.1991.*AppliedStatistics:AHandbookofGENSTATAnalyses*. ChapmanandHall.
- SprentP.1993.*AppliedNon-parametricStatisticalMethods*.2ndEd.Chapman&Hall.
- TufteER.1983.*TheVisualDisplayofQuantitativeInformation*.GraphicsPress,Cheshire, Conn.
- VellemanPFandHoaglinDC.1981.*Application,BasicsandComputingofExploratory DataAnalysis*.DuxburyPress.
- WeisbergS.1985.*AppliedLinearRegression*.JohnWiley.
- WetherillGB.1982.*ElementaryStatisticalMethods*.Chapman&Hall.
- ClevelandWS.1994.*TheElementsofGraphingData*.2ndEd.,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. CourseTitle :Mathematics-I

II. CourseCode :STAT551

III. CreditHours :3+0

IV. Aimofthecourse

This course lays the foundation of all other courses of Agricultural Statistics disciplinebypreparingthemtounderstandtheimportanceofmathematicalmethods in research. The students would be exposed to the basic mathematical tools of real analysis,calculus,differentialequationsandnumericalanalysis.Thiswouldprepare themtostudytheirmaincoursesthatinvolveknowledgeofMathematics.

V. Theory

UnitI

Calculus:Limitandcontinuity,differentiationoffunctions,successivedifferentiation, partial differentiation, mean value theorems, Taylor and Maclaurin's series. Applicationofderivatives,L'hospital'srule.

UnitII

RealAnalysis:Convergenceanddivergenceofinfiniteseries,useofcomparison tests-D'Alembert'sRatio-test,Cauchy'snthroottest,Raabe'stest,Kummer's test, Gauss test. Absolute and conditional convergence. Riemann integration, conceptof Lebesgue integration, power series, Fourier, Laplace and Laplace -Steiltjes' transformation, multiple integrals.Integrationof rational, irrational and trigonometricfunctions.Applicationofintegration.

UnitIII

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

UnitIV

NumericalAnalysis:Simpleinterpolation,Divideddifferences,Numericaldifferentiation and integration.

VI. SuggestedReading

- Bartle RG. 1976. *Elements of Real Analysis*. John Wiley. Chatterjee SK. 1970. *Mathematical Analysis*. Oxford & IBH.
- GibsonGA.1954.*AdvancedCalculus*.Macmillan.
- HenriceP.1964.*ElementsofNumericalAnalysis*.John Wiley.
- HildebrandFB.1956.*IntroductiontoNumericalAnalysis*.TataMcGrawHill.
- PriestleyHA.1985.*ComplexAnalysis*.ClarentonPress.
- Rudin W. 1985. *Principles of Mathematical Analysis*. McGraw Hill. Sauer T. 2006. *Numerical AnalysisWithCD-Rom*.AddisonWesley.ScarboroughJB.1976.*NumericalMathematical Analysis*.Oxford&IBH.StewartJ.2007.*Calculus*.Thompson.
- ThomasGB Jr. and Finney RL. 1996. *Calculus*. 9th Ed.PearsonEdu.

I. CourseTitle :ProbabilityTheory

II. CourseCode :STAT552

III. CreditHours :2+0

IV. Aimofthecourse

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 introducedtostochasticprocesses.

V. Theory

UnitI

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 andindependenceofevents.Bayestheorem.

UnitII

Randomvariables:definitionofrandomvariable,discreteandcontinuous,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.Independenceofrandomvariables.Transformationofrandomvariables (two dimensional caseonly). Mathematical expectation: Mathematical expectationof 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,probabilitygeneratingfunctionandstatementsoftheirproperties.

UnitIII

Conditional expectation and conditional variance. Characteristic function and its properties. Inversion and uniqueness theorems. Chebyshev, Markov, Cauchy-Schwartz,Sequenceofrandomvariablesandmodesofconvergence(convergencein distribution in probability, almost surely, and quadratic mean) and their interrelations.

UnitIV

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

VI. SuggestedReading

- Ash RB. 2000.*Probability andMeasure Theory*.2ndEd. AcademicPress. BillingsleyP. 1986. *ProbabilityandMeasure*.2ndEd.JohnWiley.
- CapinskiMandZastawniah.2001. *ProbabilityThroughProblems*. 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.
- LoeveM.1978.*ProbabilityTheory*.4thEd.Springer.
- MarekC,TomaszJZ.2003.*Probability*ThroughProblems(ProblemBooksinMathematics) Corrected Ed.
- MarekF. 1963. *ProbabilityTheoryandMathematicalStatistics*.JohnWiley.
- RohatgiVK&SalehAKMd.E.2005.*AnIntroductiontoProbabilityand*Statistics.2ndEd. John Wiley.

I. CourseTitle :StatisticalMethods

II. CourseCode :STAT553

III. CreditHours :2+1

IV. Aimofthecourse

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

UnitI

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.Probabilitydistributionsoffunctionsofrandomvariables.

UnitII

Concepts of compound, truncated and mixture distributions (definitions and examples).Samplingdistributionsofsamplemeanandsamplevariancefrom Normal population,centralandnon–centralchi-Square,*t*and*F*distributions,theirproperties andinterrelationships.

UnitIII

Concepts of random vectors, moments and their distributions. Bivariate Normal distribution-marginalandconditionaldistributions.Distributionofquadraticforms. Cochran theorem. Correlation, rank correlation, correlation ratio and intra-class correlation.Regressionanalysis,partialandmultiplecorrelationandregression.

UnitIV

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

UnitV

Orderstatistics,distributionof*r*-thorderstatistics,jointdistributionofseveral orderstatisticsandtheirfunctions,marginaldistributionsoforderstatistics.

VI. Practical

- Fittingofdiscretedistributionsandtestforgoodnessoffit;
- Fitting of continuous distributions and test for goodness of fit; Fitting of truncateddistribution;
- Computation of simple, multiple and partial correlation coefficient, correlationratio and intra-class correlation;
- Regressioncoefficientsandregressionequations;
- FittingofPearsoniancurves;
- Analysisofassociationbetweenattributes,categoricaldataandlog-linearmodels.

VII. SuggestedReading

- Agresti,A.2012.*CategoricalDataAnalysis*3rdEd.JohnWiley.
- Arnold BC, Balakrishnan N and Nagaraja HN. 1992. *A First Course in Order Statistics*.JohnWiley.
- David HAandNagarajaHN.2003.*OrderStatistics*.3rdEd.JohnWiley.
- DudewiczEJandMishraSN. 1988.*ModernMathematicalStatistics*.John Wiley.
- HuberPJ.1981.*RobustStatistics*.JohnWiley.
- JohnsonNL,KotzSandBalakrishnanN.2000.*ContinuousUnivariateDistributions*. JohnWiley.
- JohnsonNL,KotzSandBalakrishnanN.2000.*DiscreteUnivariateDistributions*.JohnWiley.
- MarekF.1963.*ProbabilityTheory andMathematicalStatistics*. JohnWiley.
- RaoCR.1965.*LinearStatisticalInferenceanditsApplications*.JohnWiley.
- Rohatgi VK and Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. 2ndEd. John Wiley.
- Gupta.S.P2008.*StatisticalMethods*.SultanChand&sonsEducationalPublisher

I. CourseTitle :ActuarialStatistics
II. CourseCode :STAT554
III. CreditHours :2+0

IV. Aimofthecourse

Thiscourseismeanttoexposetothestudentstothestatisticaltechniquessuch as probability models, life tables, insurance and annuities. The students would also beexposedtoppracticalapplicationsofthesetechniquesincomputationofpremiums thatincludeexpenses,generalexpenses,typesofexpensesandperpolicyexpenses.

V. Theory

UnitI

Insurance and utility theory, models for individual claims and their sums, survival function,curtatefuturelifetime,forceofmortality.

UnitII

Life table and its relation with survival function, examples, assumptions for fractionalages,someanalyticallawsofmortality,selectandultimatetables.

UnitIII

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 premiumsandtheirnumericalevaluations.

UnitIV

Distributionofaggregateclaims,compoundPoissondistributionanditsapplications.

UnitV

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

UnitVI

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,commutationfunctions.

UnitVII

Lifeannuities:Singlepayment,continuouslifeannuities,discretelifeannuities, life annuities with monthly payments, commutation functions, varying annuities, recursions,completeannuities-immediateandapportionableannuities-due.

UnitVIII

Net premiums: Continuous and discrete premiums, true monthly paymentpremiums, 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, reservesatfractionaldurations,allocationsoflosstopolicyyears,recursiveformulas anddifferentialequationsforreserves,commutationfunctions.

UnitIX

Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating theindividualmodel,stop-lossinsurance.

VI. SuggestedReading

- AtkinsonMEandDicksonDCM.2000.*AnIntroductiontoActuarialStudies*.ElgarPubl.
- BedfordTandCookeR.2001.*ProbabilisticRiskAnalysis*.Cambridge.
- BoothPM,ChadburnRG,CooperDR,Haberman,SandJamesDE.1999.Modern*Actuarial Theory and Practice*. Chapman & Hall.
- BorowiakDaleS.2003.*FinancialandActuarialStatistics:AnIntroduction*.MarcelDekker.
- Bowers NL, Gerber HU, Hickman JC, Jones DA and Nesbitt CJ.1997. *Actuarial Mathematics*. 2nd Ed. Society of Actuaries, Ithaca, Illinois.
- DaleSB, ArnoldFS. 2013.*FinancialandActuarialStatistics:AnIntroduction*,2nd Ed. (Statistics: A Series of Textbooks and Monogrphs)
- DaykinCD,PentikainenTandPesonenM.1994.*PracticalRiskTheoryforActuaries*. Chapman&Hall.
- Klugman SA, Panjer HH, Willmotand GE and Venter GG. 1998. *Loss Models: From data to Decisions*. John Wiley.
- MedinaPKandMerinoS.2003.*MathematicalFinanceandProbability:ADiscrete Introduction*.Basel,Birkhauser.
- Melnikov, A. 2011. *Risk Analysis in Finance and Insurance* (Chapman & Hall/Crc Financial

Mathematics Series) 2nd Ed.
- NeillA.1977.*LifeContingencies*.Butterworth-Heinemann.
- Rolski T, Schmidli H, Schmidt V and Teugels J. 1998. *Stochastic Processes for Insurance and Finance*. John Wiley.
- RotarVI.2006.*ActuarialModels.TheMathematicsofInsurance.Chapman*&Hall/CRC.
- SpurgeonET.1972.*LifeContingencies*.CambridgeUniv.Press.

I. CourseTitle :Bioinformatics

II. CourseCode :STAT555

III. CreditHours :2+0

IV. Aimofthecourse

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 disciplineof Agricultural Sciences. This course is meant to train the students on concepts of basicbiology,statisticaltechniquesandcomputationaltechniquesforunderstanding bioinformaticsprincipals.

V. Theory

UnitI

Basic Biology: Cell, genes, gene structures, gene expression and regulation, Molecular tools,nucleotides,nucleicacids,markers,proteinsandenzymes,bioenergetics, single nucleotide polymorphism, expressed sequence tag. Structural and functional genomics: Organization and structure of genomes, genome mapping, assembling of physicalmaps,strategiesandtechniquesforgenomesequencingandanalysis.

UnitII

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.;Searchingsequencedatabases,Structuraldatabases.

UnitIII

StatisticalTechniques:MANOVA,Clusteranalysis,Discriminantanalysis,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;

UnitIV

Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis,ApproachestoESTanalysis;Pairwisealignmenttechniques: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;DatabasesonSNPs;EMalgorithmandothermethodstodiscover common motifs in biosequences; Gene prediction based on Neural Networks, Genetic algorithms,Computationalanalysisofproteinsequence,structureandfunction; DesignandAnalysisofmicroarray/RNAseqexperiments.

VI. SuggestedReading

- Baldi P. and Brunak S. 2001. *Bioinformatics: The Machine Learning Approach.* 2nd Ed. (AdaptiveComputationandMachineLearning).MITPress.
- BaxevanisA.D.andFrancisB.F.(Eds.).2004.*BioinformaticsAPracticalGuidetothe*
- BergeronB.P.2002.*BioinformaticsComputing*.PrenticeHall.
- DudaR.O,HartP.EandStorkD.G.1999.*PatternClassification*.JohnWiley.
- EwensW.JandGrantG.R.2001.*StatisticalMethodsinBioinformatics:AnIntroduction (StatisticsforBiologyandHealth)*.Springer.
- GrahamB.Zweig,J.Buffett,WE. 2006.*TheIntelligentInvestor:TheDefinitiveBookon Value Investing.* A Book of Practical Counsel, Revised Edition
- HuntSandLivesyF.(Eds.).2000.*FunctionalGenomics:APracticalApproach(ThePractical ApproachSeries,235)*.OxfordUniv.Press.
- Jones N.C. and Pevzner P.A. 2004. *An Introduction to Bioinformatics Algorithims.* MITPress.
- KoskiTandKoskinenT.2001.*HiddenMarkovModelsforBioinformatics*.Kluwer.
- KraneD.E.andRaymerM.L.2002.*FundamentalConceptsofBio-informatics*.Benjamin/ Cummings.
- KrawetzS.AandWombleD.D.2003.*IntroductiontoBioinformatics:ATheoreticaland Practical Approach*. Humana Press.
- LeskA.M.2002.*IntroductiontoBio-informatics*.OxfordUniv.Press.
- PercusJ.K.2001.*MathematicsofGenomeAnalysis*.CambridgeUniv.Press.
- SorensenDandGianolaD.2002.*Likelihood,BayesianandMCMCMethodsinGenetics.* Springer.
- TisdallJ.D.2001.*MasteringPerlforBioinformatics*.O'Reilly&Associates.
- WangJ.T.L.,ZakiM.J.,ToivonenH.T.T.andShashaD.2004.*DataMininginBioinformatics.* Springer.
- WuC.H.andMcLartyJ.W.2000.*NeuralNetworksandGenomeInformatics*.Elsevier.
- Wunschiers R. 2004. *Computational Biology Unix/Linux, Data Processing and Programming.* Springer.

I. CourseTitle :Econometrics

II. CourseCode :STAT556

III. CreditHours :2+0

IV. Aimofthecourse

This course is meant for training the students in econometric methods and their applications in agriculture. This course would enable the students in understanding theeconomicphenomenathroughstatisticaltoolsandeconomicsprinciples.

V. Theory

UnitI

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. Maximumlikelihoodestimation.

UnitII

Heteroscedasticity, Auto-correlation, Durbin Watson test, Multi-collinearity. Stochasticregressors,Errorsinvariables,Useofinstrumentalvariablesinregression analysis. Dummy Variables. Distributed Lag models: Koyck's Geometric Lag scheme,Adaptive Expectation and Partial Adjustment Mode, Rational Expectation Models and test for rationality.

UnitIII

Simultaneous equation model: Basic rationale, Consequences of simultaneous relations,Identificationproblem,ConditionsofIdentification,IndirectLeastSquares, 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 ComponentMethods.

UnitIV

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

UnitV

Demand analysis – Demand and Supply Curves; Determination of demand curves from market data. Engel's Law and the Engel's Curves, Income distribution and methodofitsestimation,Pareto'sCurve,Incomeinequalitymeasures.

VI. SuggestedReading

- CroxtonF.E.andCowdenD.J.1979.*AppliedGeneralStatistics*.PrenticeHallofIndia.
- JamesH.S.andMarkW.W.2017.IntroductiontoEconometrics.3rdEd.JohnWiley
- JohnstonJ.1984.*EconometricMethods*.McGrawHill.
- JudgeG.C.,HillR.C.,GriffithsW.E.,LutkepohlHandLeeT.C.1988.*Introductiontothe Theory and Practice of Econometrics*. 2nd Ed. John Wiley.
- KmentaJ.1986.*ElementsofEconometrics*.2nd Ed.UniversityofMichiganPress.
- KoopG.2007.*IntroductiontoEconometrics*.JohnWiley.
- MaddalaG.S.2001.*IntroductiontoEconometrics*.3rd Ed.JohnWiley.
- Pindyck R.S. and Rubinfeld D.L. 1998. *Econometric Models and Economic Forecasts*. 4th Ed. McGraw Hill.
- VerbeekM.2008.*AGuidetoModernEconometrics*.3rd Ed.JohnWiley.

I. CourseTitle :Mathematics-II

II. CourseCode :STAT561

III. CreditHours :2+0

IV. Aimofthecourse

ThisisanothercoursethatsupportsallothercoursesinAgriculturalStatistics. The students would be exposed to the advances in Linear Algebra and Matrix theory.Thiswouldpreparethemtostudytheirmaincoursesthatinvolveknowledge of Linear Algebra and Matrix Algebra.

V. Theory

UnitI

Linear Algebra: Group, ring, field and vector spaces, Sub-spaces, basis, Gram Schmidt'sorthogonalization,Galoisfield-Fermat'stheoremandprimitiveelements. Lineartransformations.Graphtheory:Conceptsandapplications.

UnitII

MatrixAlgebra:Basicterminology,linearindependenceanddependenceofvectorsRow and column spaces, Echelon form. Determinants, Trace of matrices rank and inverse of matrices. Special matrices – idempotent, symmetric, orthogonal. Eigenvaluesandeigenvectors,Spectraldecompositionofmatrices.

UnitIII

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 rootof a symmetric matrix. Solutions of linear equations, Equations having many solutions.

UnitIV

Generalized inverses, Moore-Penrose inverse, Applications of g-inverse. Inverseand Generalized inverse of partitioned matrices, Differentiation and integration of vectorsandmatrices,Quadraticforms.

VI. SuggestedReading

- AschbacherM.2000.*FiniteGroupTheory*.CambridgeUniversityPress.
- Deo N. 1984. *Graph Theory with Application to Engineering and Computer Science*. Prentice Hall of India.
- GentleJE.2007.*MatrixAlgebra:Theory,ComputationsandApplicationsinStatistics*. Springer.
- GraybillFE.1961.*IntroductiontoMatriceswithApplicationsinStatistics*.WadsworthPubl.
- HadleyG.1969.*LinearAlgebra*.AddisonWesley.
- HarvilleDA.1997.*MatrixAlgebrafromaStatistician'sPerspective*.Springer.
- RaoCR.1965.*LinearStatisticalInferenceanditsApplications*.2nd Ed.JohnWiley.
- RobinsonDJS.1991.*ACourseinLinearAlgebrawithApplications*.WorldScientific.
- SearleSR.2006.*MatrixAlgebraUsefulforStatistics*JohnWiley,2nd Ed.
- SeberGAF.2008.*AMatrixHandbookforStatisticians*.JohnWiley.

I. CourseTitle :StatisticalInference

II. CourseCode :STAT562

III. CreditHours :2+1

IV. Aimofthecourse

This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testingofhypothesis.Theywouldalsobegiventheconceptsofnonparametricandsequential testproceduresandelementsofdecisiontheory.

V. Theory

UnitI

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-Raolowerboundanditsapplications.

UnitII

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

UnitIII

Fundamentals of hypothesis testing-statistical hypothesis, statistical test, critical region, types of errors, test function, randomized and non- randomized tests, levelof 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,asymptoticpropertiesofLRtestswithapplications(includinghomogeneity

ofmeansandvariances).Relationbetweenconfidenceintervalestimationandtesting ofhypothesis.

UnitIV

SequentialProbabilityratiotest,PropertiesofSPRT.TerminationpropertyofSPRT, 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 Minimaxdecisionfunctionswithapplicationstoestimationwithquadraticloss.

UnitV

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 independenceofattributes.Spearman'srankcorrelationandKendall'sTautests forindependence.

VI. Practical

- Methodsofestimation-MaximumLikelihood,Minimumc^2andMoments;
- ConfidenceIntervalEstimation;
- MPandUMPtests;
- LargeSampletests;
- Non-parametrictests,SequentialProbabilityRatioTest;
- Decisionfunctions.

VII. SuggestedReading

- BoxG.E.P.andTiaoG.C.1992.*BayesianInferenceinStatisticalAnalysis*.JohnWiley.
- CaselaGandBergerR.L.2001.*StatisticalInference*.DuxburyThompsonLearning.
- ChristensenR.1990.*LogLinearModels*.Springer.
- ConoverW.J.1980.*PracticalNonparametricStatistics*.JohnWiley.
- DudewiczEJandMishraSN.1988.*ModernMathematicalStatistics*.JohnWiley.
- GibbonsJ.D.1985.*NonParametricStatisticalInference*.2nd Ed.MarcelDekker.
- KieferJ.C.1987.*IntroductiontoStatisticalInference*.Springer.
- LehmannEL.1986.*TestingStatisticalHypotheses*.JohnWiley.
- LehmannEL.1986.*TheoryofPointEstimation*.John Wiley.
- RandlesR.HandWolfeD.S.1979.*IntroductiontotheTheoryofNonparametricStatistics*. John Wiley.
- RaoC.R.2009.*LinearStatisticalInferenceandItsApplications*,3rd Ed.JohnWiley.
- RohatgiV.K.andSalehA.K.Md.E.2005.*AnIntroductiontoProbabilityandStatistics*.2nd Ed. John Wiley.
- RohtagiV.K.1984.*StatisticalInference*.JohnWiley
- SidneySandCastellanN.J.Jr.1988.*NonParametricStatisticalMethodsforBehavioral Sciences*. McGraw Hill.
- WaldA.2004.*SequentialAnalysis*.DoverPubl.
- MichaelJ.Panik.2012.*StatisticalInference*.AJohnWiley&Sons,INC,publication

I. CourseTitle :DesignofExperiments

II. CourseCode :STAT563

III. CreditHours :2+1

IV. Aimofthecourse

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 coursewould

also prepare the students in deriving the expressions for analysis of experimentaldata.

V. Theory

UnitI

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

UnitII

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

UnitIII

Basic designs - completely randomized design, randomized complete block design and Latin square design; Construction of orthogonal Latin squares, mutually orthogonalLatinsquares(MOLS),Youdensquaredesigns,GraecoLatinsquares.

UnitIV

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 andconstruction, Latticedesigns, alpha designs,cyclic designs,augmented designs.

UnitV

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

UnitVI

Cross-over designs. Missing plot technique; Split plot and Strip plot design; Groups ofexperiments, Samplinginfieldexperiments.

VI. Practical

- Determinationofsizeandshapeofplotsandblocksfromuniformitytrialsdata;
- Analysisofdatageneratedfromcompletelyrandomizeddesign,randomized complete block design;
- Latinsquaredesign,Youdensquaredesign;Analysisofdatageneratedfroma BIB design, lattice design, PBIB designs;
- 2^n,3^nfactorialexperimentswithoutandwithconfounding;
- Splitandstripplotdesigns,repeatedmeasurementdesign;
- Missingplottechniques,
- Analysisofcovariance;
- AnalysisofGroupsofexperiments,
- Analysisofclinicaltrialexperiments.

VII. SuggestedReading

- ChakrabartiM.C.1962.*MathematicsofDesignandAnalysisofExperiments*.AsiaPubl.House.
- CochranW.G.andCoxD.R.1957.*ExperimentalDesigns*.2nd Ed.JohnWiley.
- DeanA.M.andVossD.1999.*DesignandAnalysisofExperiments*.Springer.
- DeyAandMukerjeeR.1999.*FractionalFactorialPlans*.JohnWiley.
- DeyA1986. *TheoryofBlockDesigns*.WileyEastern.HallMJr.1986.*CombinatorialTheory*. John Wiley.
- JohnJ.A.andQuenouilleM.H.1977.*Experiments:DesignandAnalysis*.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.

- KshirsagarA.M.1983.*ACourseinLinearModels*.MarcelDekker.
- MontgomeryD.C.2013.*DesignandAnalysisofExperiments*.JohnWiley&Sons
- Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*.John Wiley.
- SearleS.R.2006.*LinearModels*.JohnWiley.
- StreetA.P.andStreetD.J.1987.*CombinatoricsofExperimentalDesigns*.OxfordSciencePubl.
- Design Resources Server. *Indian Agricultural Statistics Research Institute (ICAR), New Delhi-110012,India*.Hyperlink"http://www.iasri.res.in/design"www.drs.icar.gov.in.

I. CourseTitle **:SamplingTechniques**

II. CourseCode **:STAT564**

III. CreditHours **:2+1**

IV. Aimofthecourse

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 samplingtechniquesandestimationofparameters.

V. Theory

UnitI

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 randomsampling,Proportionalallocationandoptimalallocation,Inversesampling.

UnitII

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 typeestimators

UnitIII

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

UnitIV

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. Inclusionprobabilityproportionaltosizesampling.

VI. Practical

- Determinationofsamplesizeandselectionofsample;
- Simple random sampling, Inverse sampling, Stratified random sampling, Cluster sampling, systematic sampling;
- Ratioandregressionmethodsofestimation;
- Doublesampling,multi-stagesampling,Imputationmethods;
- Randomizedresponsetechniques;
- Samplingwithvaryingprobabilities.

VII. SuggestedReading

- CasselC.M.,SarndalC.E.andWretmanJ.H.1977.*FoundationsofInferenceinSurvey Sampling.*

John Wiley.
- ChaudhariAandStengerH.2005.*SurveySamplingTheoryandMethods*.2nd Ed.Chapman & Hall.
- ChaudhariAandVossJ.W.E.1988.*UnifiedTheoryandStrategiesofSurveySampling*. NorthHolland.
- CochranW.G.1977.*SamplingTechniques*.JohnWiley.
- HedayatA.S.andSinhaB.K.1991.*DesignandInferenceinFinitePopulationSampling*. John Wiley.
- KishL.1965.*SurveySampling*.JohnWiley.
- Mukhopadhyay,P.2008.
- *TheoryandMethodsofSurveySampling*,JohnWiley&Sons
- MurthyM.N.1977.*SamplingTheoryandMethods*.2nd Ed. Statistical Publ. Society, Calcutta.
- SukhatmeP.V.,SukhatmeB.V.,SukhatmeSandAsokC.1984.*SamplingTheoryofSurveys withApplications*.IowaStateUniversityPressandIndianSocietyofAgriculturalStatistics, New Delhi.
- ThompsonSK.2000.*Sampling*.JohnWiley.
- KochranWG.2007.*SamplingTechniques*.AJohnWiley&Sons*Publication*

I. CourseTitle :StatisticalGenetics

II. CourseCode :STAT565

III. CreditHours :2+1

IV. Aimofthecourse

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 parametersanddevelopmentofselectionindices.

V. Theory

UnitI

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

UnitII

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,Theoryofpathcoefficients.

UnitIII

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

UnitIV

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, Maternaleffects-estimationoftheircontribution.

UnitV

Correlations between relatives, Heritability, Repeatability and Genetic correlation. Responseduetoselection,Selectionindexanditsapplicationsinplantsandanimals' improvementprogrammes,Correlatedresponsetoselection.

UnitVI

Restricted selection index. Variance component approach and linear regression

approach for the analysis of GE interactions. Measurement of stability and adaptabilityforgenotypes.Conceptsofgeneralandspecificcombiningability.Diallel andpartialdiallelcrosses-constructionandanalysis.

VI. Practical

- Testforthesinglefactorsegregationratios,homogeneityofthefamilieswithregard to single factor segregation;
- Detectionandestimationoflinkageparameterbydifferentprocedures;
- Estimationofgenotypicandgenefrequencyfromagivendata.
- Hardy-Weinberglaw;
- Estimation of changes in gene frequency due to systematic forces, inbreeding coefficient, genetic components of variation, heritability and repeatabilitycoefficient, genetic correlation coefficient;
- Examinationofeffectoflinkage,epistasisandinbreedingonmeanandvariance of metric traits;
- Matingdesigns;
- Construction of selection index including phenotypic index, restricted selection index. Correlated response to selection.

VII. SuggestedReading

- AgarwalBLandAgarwalSP.2007.*StatisticalAnalysisofQuantitativeGenetics*.NewAge International Publisher.
- BaileyNTJ.1961.*TheMathematicalTheoryofGeneticLinkage*.ClarendonPress.
- BaldingDJ,BishopMandCanningsC.2001.*HandBookofStatisticalGenetics*.JohnWiley.
- CrowJFandKimuraM.1970.*AnIntroductionofPopulationGeneticsTheory*.Harperand Row.
- DahlbergG.1948.*MathematicalMethodsforPopulationGenetics*.InterSciencePubl.
- EastEMandJonesDF.1919.*InbreedingandOutbreeding*.
- LippincottJB&Co.EwensWJ.1979.*MathematicsofPopulationGenetics*.Springer.
- FalconerDS.1985.*IntroductiontoQuantitativeGenetics*.ELBL.
- FisherRA.1949.*TheTheoryofInbreeding*.Oliver&Boyd.
- FisherRA.1950.*StatisticalMethodsforResearchWorkers.Oliver*&Boyd.
- FisherRA.1958.*TheGeneticalTheoryofNaturalSelection.Dover*Publ.
- KempthorneO.1957.*AnIntroductiontoGeneticStatistics*.ThelowaStateUniv.Press.
- LernerIM.1950.*PopulationGeneticsandAnimalImprovement*.CambridgeUniv.Press.
- LernerIM.1954.*GeneticHomeostasis*.Oliver&Boyd.
- LernerIM.1958.*TheGeneticTheoryofSelection*.JohnWiley.
- LiCC.1982.*PopulationGenetics*.TheUniversityofChicagoPress.
- K&JinksJL.1977.*IntroductiontoBiometricalGenetics*.Chapman&Hall.
- MatherKandJinksJL.1982.*BiometricalGenetics*.Chapman&Hall.
- MatherK.1949.*BiometricalGenetics*.Methuen.
- MatherK.1951.*TheMeasurementofLinkageinHeredity*.
- Methuen.N.P.1990.*StatisticalGenetics*.WileyEastern.

I. CourseTitle :StatisticalQualityControl

II. CourseCode :STAT566

III. CreditHours :2+0

IV. Aimofthecourse

This course is meant for exposing the students to the concepts of Statistical Quality Controlandtheirapplicationsinagribusinessandagro-processingindustries. 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 ofStatisticalMethods.

V. Theory

UnitI

Introduction to Statistical Quality Control; Control Charts for Variables – Mean, StandarddeviationandRangecharts;Statisticalbasis;Rationalsubgroups.

UnitII

Controlchartsforattributes-'np','p'and'c'charts.

UnitIII

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

UnitIV

Samplinginspectiontablesforselectionofsingleanddoublesamplingplans.

VI. SuggestedReading

- CowdenD.J.1957.*StatisticalMethodsinQualityControl*.PrenticeHallofIndia.
- DodgeH.F.andRomigH.G.1959.*SamplingInspectionTables*.JohnWiley.
- Duncan A.J. 1986.*QualityControl and Industrial Statistics*.5th Ed. Irwin BookCo.
- GrantE.L.andLeavenworthR.S.1996.*StatisticalQualityControl*.7thEd.McGraw Hill.
- MontgomeryD.C.2008.*IntroductiontoStatisticalQualityControl*.6thEd.JohnWiley.
- WetherhilG.B.1977.*SamplingInspectionandQualityControl*.HalstedPress.

I. CourseTitle **:OptimizationTechniques**

II. CourseCode **:STAT567**

III. CreditHours **:1+1**

IV. Aimofthecourse

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 thesetechniques.

V. Theory

UnitI

Classification of optimization problems, Classical optimization techniques: single variable optimization, multivariable optimization techniques with no constraints, multivariable optimization techniques with equality constraints, multivariable optimizationtechniqueswithinequalityconstraints.

UnitII

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

UnitIII

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

UnitIV

Quadratic programming, integer linear programming, integer nonlinear programming, geometric programming, dynamic programming, stochastic programming, multiobjective optimization, optimal control theory, genetic algorithms,simulatedannealing,neuralnetworkbasedoptimization,

VI. Practical

- Problemsbasedonclassicaloptimizationtechniques,optimizationtechniqueswith constraints, minimization problems using numerical methods.
- Linear programming (LP) problems through graphical method, simplex method, simplex two-phase method, primal and dual method.
- SensitivityanalysisforLPproblem,LPproblemusingKarmarkar'smethod.
- ProblemsbasedonQuadraticprogramming,integerprogramming,dynamic programming, stochastic programming.
- ProblemsbasedonPontryagin'smaximumprinciple.
- Problemsbasedonmultiobjectiveoptimization.

VII. SuggestedReading

- AntunesC.H.,Alves,M.J.,ClimacoJ.2016.*MultiobjectiveLinearandIntegerProgramming* (EUROAdvancedTutorialsonOperationalResearch)
- Nocedal, J. andWright, S.J. 1999.*Numerical Optimization*.Springer.
- Rao,S.S.2007.*EngineeringOptimization:TheoryandPractice*.NewAgeInternational Publishers.
- Rustagi,J.S.1994.*OptimizationTechniquesinStatistics*.Academic Press.
- Taha,H.A.2007.*OperationsResearch:IntroductionwithCD*.PearsonEducation.
- Xu,H.Teo,K.L.ZhangY.2016.*OptimizationandControlTechniquesandApplications* (SpringerProceedingsinMathematics&Statistics)
- Zeleny,M.1974.*LinearMultiobjectiveProgramming*.Springer.

I. CourseTitle :MultivariateAnalysis

II. CourseCode :STAT571

III. CreditHours :2+1

IV. Aimofthecourse

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, estimationandtestingofparameters,variousdatareductionmethodswouldhelp the students in having a better understanding of agricultural research data, its presentation and analysis.

V. Theory

UnitI

Conceptofrandomvector,itsexpectationandVariance-Covariancematrix.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 hypothesisaboutmeanvector.

UnitII

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'Ocriterionanditsproperties.Conceptsofdiscriminantanalysis,computation of linear discriminant function, classification between k ($\tau 2$) multivariate normal populations based on LDF and Mahalanobis D^2.

UnitIII

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 linkagemethods.K-meansclusteranalysis.

UnitIV

Pathanalysisandcomputationofpathcoefficients,introductiontomultidimensional scaling,sometheoreticalresults,similarities,metricandnon-metricscalingmethods.

VI. Practical

- Maximumlikelihoodestimatesofmean-vectoranddispersionmatrix;
- Testingofhypothesisonmeanvectorsofmultivariatenormalpopulations;
- Cluster analysis, Discriminant function, Canonical correlation, Principal component analysis, Factor analysis;
- Multivariateanalysisofvarianceandcovariance,multidimensionalscaling.

VII.Suggested Reading

- Abdelmonem A, Virginia AC and Susanne M. 2004. *Computer Aided Multivariate Analysis*. Chapman & Hall/CRC.
- AndersonTW.1984.*AnIntroductiontoMultivariateStatisticalAnalysis*.2nd Ed.JohnWiley.
- ArnoldSF.1981.*TheTheoryofLinearModelsandMultivariateAnalysis*.JohnWiley.
- GiriNC.1977.*MultivariateStatisticalInference*.AcademicPress.
- Johnson RA and Wichern DW. 1988. *Applied Multivariate Statistical Analysis*. PrenticeHall.
- KshirsagarAM.1972.*MultivariateAnalysis*.MarcelDekker.
- Muirhead RJ. 1982. *Aspects of Multivariate Statistical Theory*. John Wiley. Muirhead, RJ. (2005) *Aspects of Multivariate Statistical Theory*. 2nd Ed. John Wiley.
- RaoCR.1973.*LinearStatisticalInferenceanditsApplications*.2nd Ed.JohnWiley.
- RencherAC.2012.*MethodsofMultivariateAnalysis*.3rd Ed.JohnWiley.
- SrivastavaMSandKhatriCG.1979.*AnIntroductiontoMultivariateStatistics*.North Holland.

I. CourseTitle :RegressionAnalysis

II. CourseCode :STAT572

III. CreditHours :1+1

IV. Aimofthecourse

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

UnitI

Simple and Multiple linear regressions: Least squares fit, Properties and examples. Polynomialregression:Useoforthogonalpolynomials.

UnitII

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

UnitIII

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 Stagewiseregressions.

UnitIV

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

VI. Practical

- Multipleregressionfittingwiththreeandfourindependentvariables;
- Estimationofresiduals,theirapplicationsinoutlierdetection,distributionof residuals;
- Testofhomoscedasticity,andnormality,Box-Coxtransformation;
- Restricted estimation of parameters in the model, hypothesis testing, Step wiseregression analysis;
- Leastmedianofsquaresnorm,Orthogonalpolynomialfitting.

VII. SuggestedReading

- BarnettVandLewisT.1984.*OutliersinStatisticalData*.JohnWiley.
- BelsleyDA,KuhEandWelschRE.2004.*RegressionDiagnostics-IdentifyingInfluential Data and Sources of Collinearity*. John Wiley.
- Chatterjee S and Hadi AS. 2013. *Regression Analysis* by *Example*. A John Wiley & sons Publication.
- DraperNRandSmithH.1998.*AppliedRegressionAnalysis*.3rdEd.JohnWiley.
- McCullaghPandNelderJA.1999.*GeneralizedLinearModels*.2ndEd.*Chapman*&Hall.
- Montgomery DC, Peck EA and Vining GG. 2003.*Introduction to Linear Regression Analysis*. 3rdEd. John Wiley.
- RaoCR.1973.*LinearStatisticalInferenceanditsApplications*.2nd*Ed*.JohnWiley.

I. CourseTitle :StatisticalComputing

II. CourseCode :STAT573

III. CreditHours :1+1

IV. Aimofthecourse

This course is meant for exposing the students in the concepts of computational techniques.Variousstatisticalpackageswouldbeusedforteachingtheconcepts ofcomputationaltechniques.

V. Theory

UnitI

Introductiontostatisticalpackagesandcomputing:datatypesandstructures,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;

UnitII

ANOVA, regression and categorical data methods; model formulation, fitting, diagnosticsandvalidation;Matrixcomputationsinlinearmodels.Analysisofdiscrete data.Multiplecomparisons,Contrastanalysis.

UnitIII

Numerical linear algebra, numerical optimization, graphical techniques, numerical approximations,TimeSeriesAnalysis.

UnitIV

Analysis of mixed models; Estimation of variance components, Analysis ofCovariance, Fitting of non-linear model, Discriminant function; Principal component analysis. techniques in the analysis of survival data and longitudinal studies,Approachestohandlingmissingdata,andmeta-analysis

VI. Practical

- Datamanagement,Graphicalrepresentationofdata,Descriptivestatistics;
- Generallinearmodels~fittingandanalysisofresiduals,outlierdetection;
- Fittingandtestingthegoodnessoffitofprobabilitydistributions;
- Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test forlargesamples-Chi-squarestest,Ftest,Onewayanalysisofvariance,contrast and its testing, pairwise comparisons;
- Mixedeffectmodels,estimationofvariancecomponents;
- Categoricaldataanalysis,dissimilaritymeasures,similaritymeasures;
- Analysisofdiscretedata,analysisofbinarydata;
- Numericalalgorithms;
- Spatialmodeling,cohortstudies;
- Clinicaltrials,analysisofsurvivaldata;
- Handlingmissingdata.Analysisoftimeseriesdata-fittingofARIMAmodels.

VII. SuggestedReading

- AgrestiA.2013.*CategoricalDataAnalysis*.3rdEd.JohnWiley.
- EverittBS and DunnG. 1991.*Advanced MultivariateData Analysis*. 2ndEd. Arnold.
- GeisserS.1993.*PredictiveInference:AnIntroduction*.Chapman&Hall.
- Gelman A & Hill J. 2006. *Data Analysis Using Regression and Multilevel/HierarchicalModels*. Cambridge Univ. Press.
- GentleJE,HärdleWandMoriY.2012.*HandbookofComputationalStatistics-Concepts andMethods*.2ndEd.Springer.
- HanJandKamberM.2000.*DataMining:ConceptsandTechniques*.Morgan.
- HastieT,TibshiraniRandFriedmanR.2001.*TheElementsofStatisticalLearning:Data Mining. Inference and Prediction*. Springer.
- KennedyWJ&GentleJE.1980.*StatisticalComputing*.Marcel Dekker.
- MillerRGJr.1986.*BeyondANOVA,BasicsofAppliedStatistics*.JohnWiley.
- RajaramanV.1993.*ComputerOrientedNumericalMethods*.Prentice-Hall.
- RossS.2000.*IntroductiontoProbabilityModels*.AcademicPress.
- RyanBFandJoiner BL.1994. *MINITAB Handbook*.3rd Ed. Duxbury Press.
- SimonoffJS.1996.*SmoothingMethodsinStatistics*.Springer.
- Singh, AK. 2016. *Practical R-Book by Examples for Agricultural Statistics*. Deptt. Of Ag. Statistics, IGKV. Raipur
- SnellEJ.1987.*AppliedStatistics:AHandbookofBMDPAnalyses*.Chapman&Hall.
- ThistedRA.1988.*ElementsofStatisticalComputing*.Chapman&Hall.
- VenablesWNandRipleyBD.1999.*Modern Applied Statistics With S-Plus*.3rdEd.Springer.
- http://www.r-project.org/
- http://www.stat.sc.edu/~grego/courses/stat706/.
- DesignResourcesServer:www.drs.icar.gov.in.

I. CourseTitle :TimeSeriesAnalysis
II. CourseCode :STAT574
III. CreditHours :1+1

IV. Aimofthecourse

This course is meant to teach the students the concepts involved in time series data.Theywouldalsobeexposedtocomponentsoftimeseries,stationarymodels 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

UnitI

Components of a time-series. Autocorrelation and Partial autocorrelation functions, Correlogramandperiodogramanalysis.

UnitII

Linear stationary models: Autoregressive, moving average and Mixed processes. Linearnon-stationarymodels:Autoregressiveintegratedmovingaverageprocesses.

UnitIII

Forecasting:Minimummeansquareforecastsandtheirproperties,Calculating and updating forecasts.

UnitIV

Modelidentification:Objectives,Techniques,andInitialestimates.Modelestimation: Likelihood function, Sum of squares function, Least squares estimates. Seasonal models.Interventionanalysismodelsand Outlierdetection.

VI. Practical

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

VII. SuggestedReading

- Box GEP, Jenkins GM and Reinsel GC. 2007. *Time Series Analysis: Forecasting and Control.* 3rdEd. Pearson Edu.
- Brockwell PJ and Davis RA. 2002. *Introduction to Time Series and Forecasting.* 2ndEd. Springer.
- ChatterjeeS,HadiAandPriceB.1999.*Regression*AnalysisbyExamples.JohnWiley.
- DraperNRandSmithH.1998.*AppliedRegressionAnalysis*.3rdEd.JohnWiley.
- Jenkins,GM, Reinsel, GC,GretaM.L,GeorgeE.P.B.2015.*TimeSeriesAnalysis:Forecasting and Control*, Wiley Series in Probability and Statistics
- JohnstonJ.1984.*EconometricMethods*.McGrawHill.
- Judge GG, Hill RC, Griffiths WE, Lutkepohl H and Lee TC. 1988. *Introduction to the Theory and Practice of Econometrics.* 2ndEd. John Wiley.
- MontgomeryDCandJohnsonLA.1976.*ForecastingandTimeSeriesAnalysis*.McGraw Hill.
- MontgomeryDC,JenningsCAandKulahciM.2015.*IntroductiontoTimeSeriesAnalysis andForecasting*,WileySeriesinProbabilityandStatistics
- ShumwayRHandStofferDS.2006.*TimeSeriesAnalysisanditsApplications:WithR Examples.* 2ndEd. Springer.

I. CourseTitle :Demography

II. CourseCode :STAT575

III. CreditHours :2+0

IV. Aimofthecourse

This course is meant for training the students in measures of demographic indices, estimation procedures of demographic parameters. Students would also be exposed topopulationprojectiontechniquesandprincipleinvolvedinbioassays.

V. Theory

UnitI

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

UnitII

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

UnitIII

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 J Sand 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 Land 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 :STAT576

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

marginalstructuralmodels.

UnitIV

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

UnitV

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

VI. SuggestedReading

- Biswas S. 2007. *Applied Stochastic Processes. A Biostatistical and Population OrientedApproach.* Wiley Eastern Ltd.
- CollettD.2003.*ModelingSurvivalDatainMedicalResearch.*Chapman&Hall.
- CoxD.R.andOakesD.1984.*AnalysisofSurvivalData.*Chapman&Hall.
- Hosmer DW Jr. and Lemeshow S. 1999. *Applied Survival Analysis: Regression Modeling or Time to Event.* John Wiley.
- KleinJ.P.andMoeschbergerM.L.2003.*SurvivalAnalysis:TechniquesforCensoredand TruncatedData.*Springer.
- KleinbaumD.G.andKleinM2005.*SurvivalAnalysis.ASelfLearningText.*Springer.
- KleinbaumD.G.andKleinM.2005.*LogisticRegression.*2ndEd.Springer.
- LeeET.1992.*StatisticalMethodsforSurvivalDataAnalysis.*
- JohnWiley and MillerRG. 1981.*Survival Analysis.*John Wiley.
- TherneauT.M.andGrambschP.M.2000.*ModelingSurvivalData:ExtendingtheCox Model.*Springer.

I. CourseTitle :StatisticalEcology

II. CourseCode :STAT577

III. CreditHours :2+0

IV. Aimofthecourse

Thiscourseismeantforexposingthestudentstotheimportanceanduseof statistical methods in collections of ecological data, species-abundance relations, communityclassificationandcommunityinterpretation.

V. Theory

UnitI

Ecologicaldata,Ecologicalsampling:Spatialpatternanalysis:Distributionmethods, Quadrant-variancemethods,Distancemethods.

UnitII

Species-abundance relations: Distribution models, Diversity indices; Species affinity: Niche-overlapindices,interspecificassociation,interspecificcovariation.

UnitIII

Community classification: Resemblance functions, Association analysis, Cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondenceanalysis,Nonlinearordination.

UnitIV

Communityinterpretation:ClassificationInterpretationandOrdination Interpretation.

VI. SuggestedReading

- GotelliN.J.andEllisonA.M.2004.*APrimerofEcologicalStatistics*
- PielouE.C.1970.*AnintroductiontoMathematicalEcology*.JohnWiley.
- ReynoldsJ.F.andLudwigJ.A.1988.*StatisticalEcology:APrimeronMethodsand Computing*. JohnWiley.
- YoungL.J.,YoungJ.H.andYoungJ.1998.*StatisticalEcology:APopulationPerspective*. Kluwer.

Course Title with Credit load
Ph.D.inAgriculturalStatistics

CourseCode	CourseTitle	CreditHours	Semester
*STAT601	AdvancedDataAnalytics	1+2	I
*STAT602	SimulationTechniques	1+1	I
*STAT603	LinearModels	2+0	I
*STAT604	AdvancedStatisticalMethods	2+1	I
*STAT611	BaysianInference	2+0	II
STAT691	SeminarI	0+1	I
STAT692	SeminarII	0+1	II
STAT699	Research	0+75	II-VI
STAT605	ModelingTechniquesforForecasting	2+1	I
STAT606	StochasticProcesses	2+0	I
STAT607	SurvivalAnalysis	2+0	I
STAT608	SpatialStatistics	1+1	I
STAT612	AdvancedDesignofExperiments	2+1	II
STAT613	AdvancedSamplingTechniques	2+1	II
STAT614	AdvancedStatisticalGenetics	2+1	II
STAT615	AdvancedTimeSeriesAnalysis	2+0	II
STAT616	AdvancedBioinformatics	2+0	II
STAT617	AdvancedEconometrics	2+0	II
STAT618	RecentAdvancesintheFieldofSpecialization	1+0	II

*CoreCourses

CourseContents
Ph.D.inAgriculturalStatistics

I. CourseTitle :**AdvancedDataAnalytics**

II. CourseCode :**STAT601**

III. CreditHours :**1+2**

IV. Aimofthecourse

This is an advanced course in Statistical Computing that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in thisarea. This also helps prepare students for applications of this important subject to agriculturalsciencesanduseofstatisticalpackages.

V. Theory

UnitI

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

Estimationincompletetables.Goodnessoffit,choiceofamodel.Generalized Linear Model for discrete data, Poisson and Logistic regression models. Log- linearmodels.

UnitII

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

UnitIII

Computationalproblemsandtechniquesforrobustlinearregression,nonlinear and generalized linear regression problem, tree-structured regression and classification, cluster analysis, smoothing and function estimation, robust multivariate analysis.

UnitIV

Analysisofincompletedata:EMalgorithm,singleandmultipleimputations.Markov Chain, Monte Carlo and annealing techniques, Neural Networks, Association Rules and learning algorithms.

UnitV

Linearmixedeffectsmodels,generalizedlinearmodelsforcorrelateddata(including generalized estimating equations), computational issues and methods for fitting models,anddropoutorothermissingdata.

UnitVI

Multivariate tests of linear hypotheses, multiple comparisons, confidence regions, prediction intervals, statistical power, transformations and diagnostics, growthcurvemodels,dose-responsemodels.

VI.Practical

- Analysisofqualitativedata;
- Generalizedlinearforcorrelateddata;
- Generalizedlinearmodelsfordiscretedata;
- Robustmethodsofestimationandtestingofnon-normaldata;
- Robustmultivariateanalysis;
- Clusteranalysis;

- AnalysisofIncompletedata;
- Classificationandpredictionusingartificialneuralnetworks;
- MarkovChain;
- Analysisofdatahavingrandomeffectsusing Linearmixedeffectsmodels;
- Analysisofdatawithmissingobservations;
- Applicationsofmultiplecomparisonprocedures;
- BuildingSimultaneousconfidenceintervals;
- Fittingofgrowthcurvemodelstogrowthdata;
- Fittingofdose-responsecurvesandestimationofparameters.

SuggestedReading

- EverittB.S. and DunnG. 1991.*Advanced MultivariateData Analysis*. 2nd Ed. Arnold.
- GeisserS.1993.*PredictiveInference: AnIntroduction*.Chapman&Hall.
- Gentle J.E., Härdle W and Mori Y. 2004. *Handbook of Computational Statistics-Concepts and Methods*. Springer.
- HanJandKamberM.2000.*DataMining: ConceptsandTechniques*.Morgan.
- HastieT,TibshiraniRandFriedmanR.2017.*TheElementsofStatisticalLearning: Data Mining, Inference and Prediction*. Springer. 2nd Ed.
- Kennedy W.J.and GentleJ.E. 1980.*StatisticalComputing*.MarcelDekker.
- MillerR.G.Jr.1986.*BeyondANOVA.BasicsofAppliedStatistics*.JohnWiley.
- RajaramanV.1993.*ComputerOrientedNumericalMethods*.Prentice-Hall.
- RobertC.P.andCasellaG.2004.*MonteCarlo*Statistical*Methods*.2nd Ed. Springer.
- RossS.2000.*IntroductiontoProbabilityModels*.AcademicPress.
- SimonoffJ.S.1996.*SmoothingMethodsinStatistics*.Springer.
- ThistedR.A.1988.*ElementsofStatisticalComputing*.Chapman&Hall.
- VenablesW.N.andRipleyB.D.1999.*ModernAppliedStatisticsWithS-Plus*.3rd Ed.Springer.
- FreeStatisticalSoftwares:http://freestatistics.altervista.org/en/stat.php.
- DesignResourcesServer:www.drs.icar.gov.in.

I. CourseTitle :SimulationTechniques
II. CourseCode :STAT602
III. CreditHours :1+1

IV. Aimofthecourse

Thiscourseismeantforstudentswhohaveagoodknowledgein StatisticalInference and Statistical Computing. This course would prepare students for undertaking research in the area of simulation techniques andtheir applications to agricultural sciences.

V. Theory

UnitI

Uses and purposes of simulation; Classification of models, Generation and testingof random numbers, Review of simulation methods; Implementation of simulation methods-

forDiscreteandcontinuousprobabilitydistribution,samplingandresamplingmethods:th eoryandapplicationofthejackknifeandthe bootstrap.

UnitII

Randomization tests, analysis using computer software packages. Simulating multivariatedistributions,MCMCmethodsandGibbssampler.

UnitIII

Simulationofgeneralizedlinearmodelsandtimeseriesmodels,Simulateddata setstobeanalyzedusingpopularcomputersoftwarepackages.

UnitIV

Stochasticsimulation:MarkovChain,MonteCarlo,Hastings-Metropolisalgorithms,

critical slowing-down and remedies, auxiliary variables, simulated tempering, reversible-jumpMCMCandmulti-gridmethods.

VI. Practical

- Simulationfromvariousprobabilitymodels;
- Resamplingmethods,jackknifeandthebootstrap;
- Randomizationtests;
- Simulatingmultivariatedistributions,MCMCmethodsandGibbssampler;
- Simulateddatasetstobeanalyzedusingpopularcomputersoftwarepackages;
- MarkovChain,MonteCarlo,Gibbs'sampling;
- Reversible-jumpMCMCandmulti-gridmethods.

VII. SuggestedReading

- AverillM.L.2017.*Simulation,ModelingandAnalysis*.TataMcGrawHill.
- Balakrishnan N, Melas V.B. and Ermakov S. (Ed.). 2000. *Advances in Stochastic Simulation Methods*. Basel-Birkhauser.
- BanksJ.(Ed.).1998.*HandbookofSimulation:Principles,Methodology,Advances, ApplicationsandPractice*.JohnWiley.
- Brately P, Fox B.L. and Scharge L.E. 1987. *A Guide to Simulation*. Springer. Davison A.C.andHinkleyD.V.2003.*BootstrapMethodsandtheirApplication*.CambridgeUniv.Press.
- GamermanD,LopesH.F.andLopesH.F.2006.*MarkovChain*Monte*Carlo:Stochastic SimulationforBayesianInference*.CRCPress.
- GardnerF.M.andBakerJ.D.1997.*SimulationTechniquesSet*.JohnWiley.GentleJ.E. 2005.*RandomNumberGenerationandMonteCarloMethods*.Springer.
- JanacekGandLouiseS.1993.*TimeSeries:Forecasting,Simulation,Applications*.Ellis HorwoodSeriesinMathematicsanditsApplications.
- KleijnenJandGroenendaalW.V.1992.*Simulation:AStatisticalPerspective*.John Wiley.
- KleijnenJ.1974(PartI),1975(PartII).*StatisticalTechniquesinSimulation*.MarcelDekker.
- LawAandKeltonD.2000.*SimulationModelingandAnalysis*.McGrawHill.
- Press W.H., Flannery B.P., Tenkolsky S.A. and Vetterling W.T. 1986. *Numerical Recipes*. Cambridge Univ.Press.
- RipleyB.D.1987.*StochasticSimulation*.JohnWiley.RossSM.1997.*Simulation*.John Wiley.

I. CourseTitle :LinearModels

II. CourseCode :STAT603

III. CreditHours :2+0

IV. Aimofthecourse

Thestudentswouldbeexposedtothetheoryoflinearmodels,estimationofvariancecomponents for unbalanced data and advanced techniques for analysis of data inagriculture.

V. Theory

UnitI

General Gauss Markoff set up, Gauss-Markoff's theorem, Aitken's transformation. Theory of linear estimation, test of hypothesis in linear models. Analysis of variance, partitioningofdegreesoffreedom.Restrictedleastsquares.Specialcasesofone and two way classifications (including disproportionate cell frequencies andinteraction,crossandnestedclassifications).

UnitII

Analysis of covariance. Variance components models, estimation of variance components from unbalanced data. Unified theory of least-squares, MINQUE, MIVQUE.Mixedmodels.LAR,LASSO.

VI. SuggestedReading

- Bapat,R.B.2012.*LinearAlgebraandLinearModels*.Springer-Verlag.

- Graybill,F.A.1976.*TheoryandApplicationoftheLinearModel*.Duxbury,NorthScituate.
- Joshi,D.D.1987.*LinearEstimationandDesignofExperiments*.WileyEastern.
- Rao,C.R.2001.*LinearInferenceanditsApplication*.WileyEastern.
- Searle,S.R.1998.*VarianceComponents*.JohnWiley.
- Searle,S.R.1971.*LinearModels*.JohnWiley.
- Seber,G.A.F.1996. *TheLinearHypothesis:AGeneralTheory*.Griffin,CharlesandCo.Ltd.
- Sheffe,H.1999.*AnalysisofVariance*.JohnWiley.

I. CourseTitle :AdvancedStatisticalMethods

II. CourseCode :STAT604

III. CreditHours :2+1

IV. Aimofthecourse

This is an advanced course in Statistical Methods that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in thisarea. This also helps prepare students for applications of this important subject to agriculturalsciences.

V. Theory

UnitI

Truncated and compound distributions. Fitting of orthogonal polynomials. Pearsoniancurves.Categoricaldataanalysis-loglinearmodels,Associationbetween attributes.Variancestabilizingtransformations.

UnitII

Sampling distribution of correlation coefficient, regression coefficient, correlation ratio,intraclasscorrelationcoefficient.

UnitIII

Non-central t, $\Phi^2$and F distributions. Distribution of quadratic forms. Cochran's theorem.Testsfornormality.Largesampletests.Testsofsignificancebasedont, Φ^2andFdistributions.Orderstatistics,distributionofr^{th}orderstatistics,joint distribution of several order statistics andtheir functions, marginal distributions of orderstatistics,distributionofrange,median,etc.

UnitIV

Fittingofageneralizedlinearmodel,mixedmodelandvariancecomponents estimation,MINQUE,MIVQUE,REML.

VI. Practical

- Fittingoftruncateddistribution,
- FittingofPearsoniancurves,
- Analysis ofassociationbetweenattributes,categoricaldata.
- Fittingof non-central t, $\Phi^2$and Fdistributions.
- ComputationofTestsofsignificancebasedont,Φ^2andFdistributions.
- Orderstatistics.

VII. SuggestedReading

- Chatterjee S, Hadi A and Price B. 2013. *Regression Analysis by Examples*. 5thEd. JohnWiley.
- DraperN.R.andSmithH.1998.*AppliedRegressionAnalysis*.3rdEd.JohnWiley.
- RaoC.R.2009.*LinearStatisticalInferenceanditsApplications*.2ndEd.JohnWiley.
- SearleS.R,CasellaGandMcCullochC.E.1992.*VarianceComponents*.JohnWiley.

• SearleS.R.1971.*LinearModels*.JohnWiley.

I. CourseTitle :ModelingTechniquesforForecasting

II. CourseCode :STAT605

III. CreditHours :2+1

IV. Aimofthecourse

This is an advanced course in Statistical Methods that aims at describing some advanced level topics in this area of research with a very strong potential of applications.Thiscoursealsopreparesstudentsforundertakingresearchinthe area of empirical and mechanistic models and nonlinear estimation and the replicationsindifferentdisciplinesofagriculturalsciences.

V. Theory

UnitI

Empirical and mechanistic models. Nonlinear growth models: monomolecular, logistic,Gompertz,Richards.Applicationsinagricultureandfisheries.

UnitII

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

UnitIII

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

UnitIV

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

UnitV

Forecastingtechniqueswithspecialreferencetoagriculture.Forecastbasedon time series data: exponential smoothing, Box – Jenkins approach and non-linear models.Forecastmodelsusingweatherparameters,crop-weatherrelationships andtheiruseinyieldforecast.Forecastusingplantcharacters.

UnitVI

Forecast surveys, between-year models (regression model, Markov chain probability model and group method of data handling) and within-year models. Agro-meteorological models: climatic water balance model and crop yield assessment. Forewarningofcroppestsanddiseases.Applicationofremotesensingtechniques inforecasting.UseofANNinforecasting.

VI. Practical

- Fittingofmechanisticnon-linearmodels;
- ApplicationofSchaeferandFoxnon-linearmodels;
- Fittingofcompartmentalmodels.Fittingofforecastmodelsusingweather parameters.
- Timeseriesanalysis:plots,decomposition,stationaritytests,exponential smoothing.•UnivariateBox–JenkinsARIMAmodelsandseasonalARIMAmodels.
- Forecastmodelsusingplantcharacters,
- AgrometeorologicalmodelsforcropforecastingMarkovchainmodelsandANN models.

VII. SuggestedReading

- Draper,N.R.andSmith,H.1998.*AppliedRegressionAnalysis*.3rdEd.John Wiley.
- EfromovichS.1999.*NonparametricCurveEstimation*.Springer.
- Fan,J.andYao,Q.2003. *NonlinearTimeSeries-NonparametricandParametricMethods*. Springer.
- France,J.andThornley,J.H.M.1984.*MathematicalModelsinAgriculture*.Butterworths.
- Harvey, A.C. 1996. *Forecasting, Structural Time Series Models and the Kalman Filter*.Cambridge Univ. Press.
- Makridakis,S.,Wheelwright,S.C.andHyndman,R.J.1998.*Forecasting:Methodsand Applications*.JohnWiley.
- Pankratz,A.1983.*ForecastingwithUnivariateBoxJenkinsModels:ConceptsandCases*. JohnWiley.
- Thornley,J. and France J.2006. *Mathematical Models in Agriculture: Quantitative Methods for the Plant, Animal and Ecological Sciences* (Cabi) 2nd Ed.

I. CourseTitle :StochasticProcesses

II. CourseCode :STAT606

III. CreditHours :2+0

IV. Aimofthecourse

This is a course on Stochastic Processes that aims at describing some advancedleveltopicsinthisareaofresearchwithaverystrongpotentialofapplications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

V. Theory

UnitI

Introduction to stochastic process - classification according to state space and time domain. Finite and countable state Markov chains; time- homogeneity; Chapman-Kolmogorov equations, marginal distribution and finite dimensional distributions. ClassificationofMarkovchain.Canonicalformoftransitionprobabilitymatrixof a Markov chain. Fundamental matrix; probabilities of absorption from transient states into recurrent classes in a finite Markov chain, mean time for absorption. ErgodicstateandErgodicchain.Stationarydistributionofa Markovchain,existence and evaluation of stationary distribution. Random walk and gamblers ruin problem.

UnitII

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

UnitIII

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

UnitIV

Stochastic process in biological sciences: Markov models in population genetics, compartmental analysis. Simple deterministic and stochastic epidemic model. Generalepidemicmodels-KarmackandMcKendrick'sthresholdtheorem.Recurrent epidemics.

UnitV

Elements of queueing process; the queuing model M/M/1: steady state behaviors.

Birth and death process in queuing theory- Multi channel models. Network of Markovianqueuingsystem.

UnitVI

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

UnitVII

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

VI. SuggestedReading

- AdkeSRandManjunathSM.1984.*FiniteMarkovProcesses*.JohnWiley.
- BaileyNTJ.1964. *ElementsofStochasticProcesseswithApplicationstotheNaturalSciences*. Wiley Eastern.
- BartlettMS.1955.*IntroductiontoStochasticProcesses*.CambridgeUniv.Press.
- BasawalVandPrakasaRaoBLS.1980.*StatisticalInferenceforStochasticProcesses*. Academic Press.
- Bharucha-ReidAT.2012.*ElementsoftheTheoryofMarkovProcessesandtheirApplications*. McGrawHill.
- BhatBR.2000.*StochasticModels;AnalysisandApplications*.NewAge.
- DraperNRandSmithH.1981.*AppliedRegressionAnalysis*.WileyEastern.FranceJ &Thornley JHM. 1984. *Mathematical Models in Agriculture*. Butterworths.
- LawlerGF.2006.*IntroductiontoStochasticProcesses*.Chapman&Hall.2nd Ed.
- MedhiJ.2001.*StochasticProcesses*.2nd Ed.WileyEastern.
- Prakasa Rao BLS and Bhat BR.1996. *Stochastic Processes and Statistical Inference*. New Age.
- RatkowskyDA.1983.*NonlinearRegressionModelling:aUnifiedPracticalApproach*.Marcel Dekker.
- RatkowskyDA.1990.*HandbookofNonlinearRegressionModels*.MarcelDekker.
- SeberGAFandWildCJ.1989.*Non-linearRegression*.JohnWiley.

I. CourseTitle :SurvivalAnalysis

II. CourseCode :STAT607

III. CreditHours :2+0

IV. Aimofthecourse

Thecoursedealswiththestudyofdemographicprofilesandsurvivaltimes.In-depthstatisticalpropertiesandanalysisisanimportantcomponentofthiscourse.

V. Theory

UnitI

Measures of Mortality and Morbidity: Ratios and proportions, rates of continuous process,ratesofrepetitiveeventscrudebirthrate,Mortalitymeasuresusedin vital statistics relationships between crude and age specific rates, standardized mortality ratios evaluation of person-year of exposed to risk in long term studies, prevalence and incidence of a disease, relative risk and odds ratio. Survival Distribution: Survival functions, hazard rate, hazard function, review of survival distributions: exponential, Weibull, Gamma, Rayleigh, Pareto, Lognormal~ IFRandTFRA,GompertzandMakeham.Gompertzandlogisticdistributions.Parametric (m.l.e) estimation. Types of Censoring: Type I, Type II, random and other types of censoring, right and left truncated distributions. Expectation and variance of future

life time, series and parallel system of failures. Life Tables: Fundamental and construction.

UnitII

Complete Mortality data, Estimation of Survival Function: Empirical survival function, estimation of survival function from grouped mortality data, joint distributionofthenumberofdeaths,distributionoftheestimationP,covariance of estimate, estimation of curves of deaths and central death rate and force of mortality rate. Incomplete Mortality data (non-parametric models): Actuarial method,m.1.emethod,momentandreducedsamplemethodofestimationand their comparison. Product limit (Kaplan-Meier) method and cumulative hazard function (CHF) of estimation of survival function.

UnitIII

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

UnitIV

ConcomitantVariables:Generalparametricmodelforhazardfunctionwithobserved concomitant variables. Additive and multiplicative models of hazard rate functions. Estimatingmultiplicativemodels,selectionofconcomitantvariables.Logisticlinear model, Concomitant Variable regarded as random variable. Age of onset distributions: Models of onset distributions and their estimation. Gompertz distribution, parallel system and Weibull distribution, Fatal short models of failure. Twocomponentseriessystem.

UnitV

Interval CensoringCompeting Risk Theory: Indices for measurement of probability ofdeathundercompetingrisksandtheirinter-relations.ConceptofCOX regressionStochastic Epidemic Models: Simple epidemic models, general epidemic modeldefinitionandconcept(withoutderivation).Durationofanepidemic.

VI. SuggestedReading

- AndersonB.1990.*MethodologicalErrorsinMedicalResearch*.Blackwell.
- ArmitagePandBerryG.1987.*Statistical*Methods*inMedicalResearch*.Blackwell.
- Biswas, S. 2007. *Applied Stochastic Processes*: *A Biostatistical and Population Oriented Approach*, 2nd Ed., New Central Book Agency.
- CollettD.2014.*ModelingSurvivalDatainMedicalResearch*.Chapman&Hall.3rd Ed.
- CoxD.R.andOakesD.1984.*AnalysisofSurvivalData*.Chapman&Hall.
- Elandt-Johnson R.C. and Johnson N.L. 1980. Survival *Models and Data Analysis*. JohnWiley.
- EverittB.S.andDunnG.1998.*StatisticalAnalysisofMedicalData*.Arnold.HosmerD.W. Jr.andLemeshowS.1999.*AppliedSurvivalAnalysis:RegressionModelingorTimetoEvent*.

JohnWiley.
- Indrayan,A. 2008.*Medical Biostatistics*, 2nd Ed.Chapman and Hall/CRC.
- LeeE.T.1980. *StatisticalMethodsforSurvivalDataAnalysis*.LifetimeLearning Publ.
- KalbfleischJ.D.andPrentice.R.L.2002.*TheStatisticalAnalysisofFailureTimeData*. John Wiley.
- KleinJ.P.andMoeschbergerM.L.2003.*SurvivalAnalysis:TechniquesforCensoredand TruncatedData*.Springer.
- KleinbaumD.G.andKleinM.2002.*LogisticRegression*.Springer.
- KleinbaumD.G.andKleinM.2005.*SurvivalAnalysis*. Springer.

I. CourseTitle :SpatialStatistics

II. CourseCode :STAT608

III. CreditHours :1+1

IV. Aimofthecourse

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

V. Theory

UnitI

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

UnitII

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

UnitIII

Spatial Sampling – Methods and procedures, Statistical Analysis of Spatial Point Process – homogenous Poisson Process, Spatial interpolation – non-statistical methods;Variogrammodelling;SpatialPrediction–SimpleKriging,Co-kriging;

UnitIV

Modelling Areal data – Autoregressive and spatial regression models and model diagnostics. Examples of Spatial Data analysis in Agriculture– Disease Mapping; IncorporatingspatialeffectsinAgriculturalFieldexperiments

VI. Practical

- SpatialData–Import,export;
- SpatialClassesinR;
- VisualizingSpatialData;
- SpatialAuto-correlation;
- Spatial Sampling, Spatial Interpolation, Spatial Autoregressive Models, Spatial Regression Model

VII. SuggestedReading

- Cressie,N.A.C.1993.*StatisticsforSpatialData*.RevisedEdition.JohnWiley
- RichardE.P.2018.*SpatialDataAnalysisinEcologyandAgricultureUsingR*,2nd Ed.
- RogerS.Bivand,EPebesmaJ.andRubioB.G.2008. *AppliedSpatialDataAnalysis using R*.Springer-Verlog.

I. CourseTitle :BaysianInference

II. CourseCode :STAT611

III. CreditHours :2+0

IV. Aimofthecourse

Thiscourseaimsatdescribingtheadvancedleveltopicsinstatisticalmethodsand statistical inference. This course would prepare students to have a strong base in basic statistics that would help them in undertake basic and applied research in Statistics.

V. Theory

UnitI

IntroductionandhistoryandcriticismofBayesianApproach;Subjective interpretation of Probability, Review of Bayes Theorem, Sufficiency, Likelihood Principle.

UnitII

Subjective Prior distribution of a parameter; Posterior Distribution of parameters usingBayesTheorem

UnitIII

InformativeandnON-informativepriorsforLocationandscale;Conjugatefamilies –DiscreteandContinuousandinterpretationofHyper-parametersofconjugates.

UnitIV

Non-informative,improperandinvariantpriorsforlocationandscaleandingeneral settings.

UnitV

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

UnitVI

Bayesian Hypothesis Testing - Specification of the appropriate form of the prior distributionforaBayesiantestingofhypothesisproblem.Priorodds,Posterior odds,Bayesfactorforvarioustypesoftestinghypothesisproblems

UnitVII

BayesianPrediction;NumericalandMonte-CarloIntegrations

UnitVIII

ApplicationsofBayesianInference-BayesianDataAnalysis

VI. SuggestedReading

- Berger,J.O.1985.*StatisticalDecisionTheoryandBayesianAnalysis*,SpringerVerlag.
- Box,G.P.andTiao,G.C.1992.*BayesianInferenceinStatisticalAnalysis*,Addison–Wesley
- Pilon C.D. 2015. *Bayesian Methods for Hackers: Probabilistic Programming and BayesianInference* (Addison-Wesley Data and Analytics)

I. CourseTitle :AdvancedDesignofExperiments

II. CourseCode :STAT612

III. CreditHours :2+1

IV. Aimofthecourse

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

V. Theory

UnitI

General properties and analysis of block designs. Balancing criteria. *m*- associate PBIB designs, and their association schemes including lattice designs - properties and construction, Designs for test treatment – control(s) comparisons; Nested block designs,Matingdesigns.StructurallyIncompleteblockdesigns

UnitII

General properties and analysis of two-way heterogeneity designs, Youden typedesigns,generalizedYoudendesigns,PseudoYoudendesigns.,Designsfortwosets oftreatments.

UnitIII

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

UnitIV

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

UnitV

Optimalitycriteriaandoptimalityofdesigns,robustnessofdesignsagainstlossof data,outliers,etc.Diagnosticsindesignofexperiments.

VI. Practical

Analysis of block designs, Analysis of Latin square type designs, group divisible designs, triangular designs, lattice designs. Analysis of fractional replications of factorial experiments, analysis of asymmetrical factorials and block designs with factorialstructure.Analysisofsecondorderresponsesurfacedesigns.

VII. SuggestedReading

- ChakrabortiM.C.1962.*MathematicsofDesignandAnalysisofExperiments*.AsiaPubl.House.
- DeanA.M.andVossD.1999.*DesignandAnalysisofExperiments*.
- pringer.DeyAandMukerjeeR.1999.*FractionalFactorialPlans*.JohnWiley.
- DeyA1986.*TheoryofBlockDesigns*.WileyEastern.
- HallMJr.1986.*CombinatorialTheory*.JohnWiley.
- HedayatA.S.,SloaneN.J.A.andStufkenJ.1999.*OrthogonalArrays:TheoryandApplications*. Springer.
- JohnJ.A.andQuenouilleM.H.1977.*Experiments:DesignandAnalysis*.CharlesandGriffin.
- Khuri A.I. and Cornell J.A. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.
- MontgomeryD.C.2005.*DesignandAnalysisofExperiments*.JohnWiley.
- OgawaJ.1974.*StatisticalTheoryoftheAnalysisofExperimentalDesigns*.MarcelDekker.
- Parsad R, Gupta V.K., Batra P.K., Satpati S.K. and Biswas P. 2007. *Monograph on a-designs*. IASRI, New Delhi.
- RaghavaraoD.1971.*ConstructionandCombinatorialProblemsinDesignofExperiments*. JohnWiley.
- ShahK.R.andSinhaB.K.1989.*TheoryofOptimalDesigns.LecturenotesinStatistics*.Vol. 54.Springer.
- SharmaM.K.2012.*DesignandAnalysisofExperiments*.KindleEd.1st Ed.

- StreetA.P.andStreetD.J.1987.*CombinatoricsofExperimentalDesigns*.OxfordScience Publ.
- DesignResourcesServer:www.drs.icar.gov.in.

I. CourseTitle :AdvancedSamplingTechniques

II. CourseCode :STAT613

III. CreditHours :2+1

IV. Aimofthecourse

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

V. Theory

UnitI

OptimumStratification,two-waystratification,collapsedstrata,Controlledselection, Useofcombinatoricsincontrolledselection,Systematicsamplingintwodimensions. Sampling with varying probabilities without replacement, Horvitz – Thompson estimator

UnitII

Variance estimation in complex surveys. Taylor's series linearization, balanced repeated replication, Jackknife and bootstrap methods.Ordered and unordered estimators,Samplingstrategies,Midzuno-Sen,Rao-Hartley-Cochran,ðPSSampling: proceduressuchasBrewer,DurbinandSampford,

UnitIII

Unifiedtheoryofsamplingfromfinitepopulations.UMV-Non-existencetheorem and existence theorem under restricted conditions. Concept of sufficiency andlikelihoodinsurveysampling.Admissibilityandhyper-admissibility.

UnitIV

Post-stratified estimator, imperfect frames, multiple frames, randomized response techniques. Inference under super population models - concept of designs andmodel unbiasedness, prediction approach. Regression analysis and categorical data analysiswithdatafromcomplexsurveys.Domainestimation.Smallareaestimation. Longitudinalsurvey.

VI. Practical

- Samplingwithvaryingprobability,
- Orderedandun-orderedestimators,
- Sampling strategies due to Horvitz-Thompson, Midzuno-Sen, Rao-Hartley-Cochran and PPS sampling: procedures such as Brewer, Durbin and Sampford, etc.
- Imperfectframes,Randomizedresponsetechnique.
- Smallareaestimation.

V. SuggestedReading

- BergerJ.O.1993.*StatisticalDecisionTheoryandBayesianAnalysis*.Sringer.
- BolfarineHandZacksS.1992.*PredictionTheoryforFinitePopulationSampling*.Springer.
- CasselC.M.,SarndalC.EandWretmanJ.H.1977.*FoundationsofInferenceinSurvey Sampling*. John Wiley.
- DesRajandChandhok P.1998.*Sample SurveyTheory*. NarosaPubl.
- House.GhoshMandMeedenG.1997.*BayesianMethodforFinitePopulation*

- *Sampling.MonographonStatisticsandAppliedProbability.*ChapmanandHall.
- MukhopadhyayP.1998.*TheoryandMethodsofSurveySampling.*PrenticeHallof India.
- RaoJ.N.K.2003.*SmallAreaEstimation.*JohnWiley.
- SarndalC.E.,SwenssonBandWretmanJ.H.1992.*ModelAssistedSurveySampling.* Springer.

I. CourseTitle :AdvancedStatisticalGenetics

II. CourseCode :STAT614

III. CreditHours :2+1

IV. Aimofthecourse

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

V. Theory

UnitI

Hardy-Weinberglawwithmultipleallelicsystems,auto-tetraploidsandself-sterility alleles.Complexcasesofselectionwithtwoormoreloci.

UnitII

Different approaches to study inbreeding process, methods of path co- efficient, probability and generation matrix. Fisher's approach to inbreeding. Stochastic process of gene frequency change, transition matrix approach using finite Markov chains, diffusion approximation, Steady decay and distribution of gene frequency, Probabilityoffixationofagene,Conditionalprocess-Markovchainsanddiffusion approaches, Distribution of time until fixation, random fluctuations in selection intensity,stationarydistributionofgenefrequency.Effectivepopulationsize.

UnitIII

Prediction and estimation of genetic merit. Best linear unbiased prediction, Use of mixed model methodology in analysis of animal and plant breeding experiments. Newer reproductive technology and its effect in genetic evaluation of individual merit.Estimationofgeneticparameters-problemsrelatingtocomputationalaspects ofgeneticvariancecomponents,parameterestimationinvariancecomponentmodels for binary response data.

UnitIV

Identification of genes with large effects, Use of molecular markers (RFLP, PCR-AFLP, RAPD and SSR), Gene mapping and Quantitative trait loci. Molecular manipulation for genetic variability.

UnitV

Variance component approach and linear regression approach for the analysis ofGE interactions.Measurement of stability and adaptability for genotypes. Concepts of general and specific combining ability, diallel and partial diallel crosses: constructionandanalysis.

VI.Practical

- Hardy-Weinberglaw,
- Estimationof genetic load and random genetic drift.
- Effectoffinitepopulationsize.

- Estimationofpathcoefficients.
- Detection and estimation of multiple allelism in continuous variation, sexlinked genes, maternal effects.
- AnalysisofG×Einteraction,measurementofstabilityandadaptability.
- Analysisofdataofdiallelandpartialdiallelcrosses.

VII. SuggestedReading

- Crow J.F. and Kimura M. 1970. *An Introduction of Population Genetics Theory*. Harper &Row.
- EwensW.J.1979.*MathematicalPopulationGenetics*.Springer.
- FalconerD.S.1985.*IntroductiontoQuantitativeGenetics*.ELBL.
- FisherR.A.1949.*TheTheoryofInbreeding*.Oliver&Boyd.
- FisherR.A.1958.*TheGeneticalTheoryofNaturalSelection*.DoverPubl.
- HaldaneJ.B.S.1932.*TheCausesofEvolution*.Harper&Bros.
- KempthorneO.1957.*AnIntroductiontoGeneticStatistics*.TheIowaStateUniv.Press.
- LernerI.M.1950.*PopulationGeneticsandAnimalImprovement*.CambridgeUniv.Press.
- LernerI.M.1958.*TheGeneticTheoryofSelection*.JohnWiley.
- LiC.C.1982.*PopulationGenetics*.TheUniversityofChicagoPress.
- MatherKandJinksJ.L.1982.*BiometricalGenetics*.Chapman&Hall.
- MatherK.1951.*TheMeasurementofLinkageinHeredity*.
- Methuen.NagilakiT.1992.*IntroductiontoTheoreticalPopulationGenetics*.Springer.
- NarainP.1990.*StatisticalGenetics*.WileyEastern.
- NielsenR.MontgomeryS.2013.*AnIntroductiontoPopulationGenetics:TheoryandApplications* 1st Ed.

I. CourseTitle :AdvancedTimeSeriesAnalysis

II. CourseCode :STAT615

III. CreditHours :2+0

IV. Aimofthecourse

This is an advanced course in Time Series Analysis that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in thisarea. This also helps prepare students for applications of this important subject to agriculturalsciences.

V. Theory

UnitI

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

UnitII

Volatility: The class of ARCH and GARCH models; Extensions of GARCH models: TGARCH,IGARCH,PGARCH,EGARCH,GJR-GARCH,ARCHandGARCHmodel with-tdistributederror;ARCD(Auto-RegressiveConditionalDensity),Multivariate GARCHmodel:estimation,analysisandforecasting,stochasticvolatility.

UnitIII

Structural time-series modelling: State space models, Kalman filter, Local level model, Local linear trend model, Seasonal models, Cyclical models. Threshold and Functionalcoefficientautoregressivemodels,StructuralBreakintimeseries.

UnitIV

Fuzzy time series models, Artificial Neural Network (ANN) methodology, Support vectormachines,Waveletsfortimeseriesanalysis,combinationsoftimeseries models.

VI. SuggestedReading

- Box G.E.P., Jenkins G.M. and Reinsel G.C. 2015. *Time Series Analysis: Forecasting and Control*. 5thEd. John Wiley.
- BrockwellP.J.andDavisR.A.1991.*TimeSeries:TheoryandMethods*.2ndEd.Springer.
- Chatfield C. 2004. *The Analysis of Time Series: An Introduction*. 6thEd. Chapman& Hall/ CRC.
- JohnstonJ.1984.*EconometricMethods*.McGrawHill.
- Singh,P.2016.*ApplicationsofSoftComputinginTimeSeriesForecasting:Simulationand Modeling Techniques*. Springer International Publishing AG
- TongH.1995.*NonlinearTimeSeries:ADynamicalSystemApproach*.OxfordUniv.Press.
- Vapnik,V.N.(2000).*TheNatureofStatisticalLearningTheory*.Springer-Verlag,New York.
- Percival,D.B.andWalden,A.T.2000.*WaveletMethodsforTime-SeriesAnalysis*.Cambridge UniversityPress,U.K.

I. CourseTitle **:AdvancedBioinformatics**

II. CourseCode **:STAT616**

III. CreditHours **:2+1**

IV. Aimofthecourse

This is a course on Bioinformatics that aims at exposing the students to some advanced statistical and computational techniques related to bioinformatics. This course would prepare the students in understanding bioinformatics principles and theirapplications.

V. Theory

UnitI

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

UnitII

Computational analysis of protein sequence, structure and function. Expression profilingbymicroarray/genechip/RNAseq,proteomicsetc.,Multiplealignmentof protein sequences, Modelling and prediction of structure of proteins, Designer proteins,Drugdesigning.

UnitIII

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

UnitIV

Markov Chains (MC with no absorbing states, higher order Markov dependence,

patterns insequences, Markov Chain Monte Carlo – Hastings-Metropolis algorithm, simulated annealing,MC with absorbing States). Bayesian techniques and use of Gibbs Sampling. Advanced topicsin design and analysis of DNA microarray experiments.

UnitV

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

UnitVI

Phylogenetic tree estimation (Distances; Tree reconstruction – Ultrametric and Neighbor-Joining cases; Surrogate distances; Tree reconstruction; Parsimony and Maximum Likelihood; Modeling, Estimation and Hypothesis Testing;) Neural Networks (Universal Approximation Properties; Priors and Likelihoods, Learning Algorithms – Backpropagation; Sequence encoding and output interpretation; Prediction of Protein Secondary Structure; Prediction of Signal Peptides and their cleavage sites; Application for DNA and RNA Nucleotide Sequences), Analysis of SNPsandHaplotypes.

VI. Practical

- Genomic databases and analysis of high-throughput data sets, BLAST and related sequence comparison methods.
- Statisticalmethodstodiscovercommonmotifsinbiosequences.
- Multiplealignmentanddatabasesearchusingmotifmodels,clustalw,classificatory analysis, neural networks, genetic algorithms, pattern recognition,
- HiddenMarkovmodels.
- Computationalanalysisofproteinsequence.
- Expressionprofilingbymicroarray/genechip,proteomics.
- Modellingandpredictionofstructureofproteins.
- BayesiantechniquesanduseofGibbsSampling.
- AnalysisofDNAmicroarrayexperiments.
- AnalysisofoneDNAsequence,multipleDNAorproteinsequences.
- Computationallyintensivemethods,multiplehypothesistesting,
- Phylogenetictreeestimation,
- AnalysisofSNPsandhaplotypes.

VII. SuggestedReading

- BaldiPandBrunakS.2001.*Bioinformatics:TheMachineLearningApproach*.MITPress.
- BaxevanisADandFrancisBF.(Eds.).2004.*Bioinformatics:APracticalGuidetotheAnalysisofGene sandProteins*.JohnWiley.
- DudaRO,HartPEandStorkDG.1999.*PatternClassification*.JohnWiley.
- Ewens WJ and GrantGR. 2001.*Statistical Methodsin Bioinformatics*.Springer.
- JonesNCandPevznerPA.2004.*IntroductiontoBioinformaticsAlgorithms*.TheMITPress.
- KoskinenT.2001.*HiddenMarkovModelsforBioinformatics*.Kluwer.
- KraneDEandRaymerML.2002.*FundamentalConceptsofBio-informatics*.
- Benjamin/Cummings.
- KrawetzSA&WombleDD.2003.*IntroductiontoBioinformatics:ATheoreticalandPractical Approach*. Humana Press.
- LeskAM.2002.*IntroductiontoBio-informatics*.OxfordUniv.Press.