SantGadgeBabaAmravatiUniversity,Amravati

Faculty of Science and TechnologyProgramme:**M.Sc. II Statistics (NEP)**

ProgramOutcomes(POs)

Attheend oftheprogramme,studentswouldbeableto

PO1: **Critical Thinking**: Think critically for data driven solution with advanced Methodology. Students may beabletothinkcriticallyeverythingaroundhim/her.Theywillbeabletotakebetteractioninanycriticalsituationin theirlife.

PO2:Nurture their curious minds toward translation and application & Statistical knowledgeto find solutionsto real worldproblems.

PO3:**Employability**:getknowledgeandskillsindepthnecessaryforemployabilityofstudentsinindustry,GovtSector andorganizationsaswell asinacademics.

PO4:**Empowerment**:beempoweredtoinvestigate,solvequestionsforwhichanswerliesbeyondtheboundariesof conventional thinking.

PO5: **Effective decision making**: take proper decision in critical and complicatedsituations. Reduce risk factorand be able tomaximize project.

PO6:**Effectivecitizenship**:getacquaintedwiththeneedsoftheindustryandsociety,andtheybecometheassetsfor the society.

PO7:**Socialinteraction**:Developsensitivityforsocialissuesandbecomeproductivecitizenofthenation.

ProgramSpecificoutcomes(PSOs)

Uponcompletionoftheprogrammesuccessfully,studentswouldbeableto

PSO1:understandbasictheoreticalandappliedprinciplesofStatisticsneededtoenterthejobforce.Theywillbeable to communicate key statistical concepts to non-statisticians.They also gain proficiency in using statisticalideas/principlesfordata analysis.

PSO2:groom as the next generation statisticians ready for scientific decision making, aided with advancedstatisticalsoftwaretranslating into sharp andextensiveanalyticspertinentto variousdomains.

PSO3:startconsultancyforstatisticalanalysisandcanbehelpfulininterdisciplinaryresearch.

PSO4: perform Statistical quality control, which is the most important sector of any industry where students canworkasstatisticianstoapprove the quality.

EmployabilityPotentialoftheprogramme

The programme offers many opportunities, where statistician can work.By completingthisprogramme,studentsare ableto:

- Analysethethings
- Understandpatternsinthembyaskingdifferentquestionstoit
- CompetewiththecurrentdemandoffField

- Tosolveaspecificproblem

This“skill”isakeyrequirementformanyanalysistypejobslike,

1. Statisticians
2. BusinessAnalyst
3. Mathematician
4. Professor
5. RiskAnalyst
6. DataAnalyst
7. ContentAnalyst
8. StatisticTrainer

Besides all these students can work in various banking sector.Studentscan alsowork in governmentsector:

- Indianstatisticalservices(ISS)
- Staffselectionservices(SSC)
- Reserve Bank of India (Junior statistical officer)
  By taking theprogramme, studentsareableto:

- Analysenumbers
- Understandpatternsinthembyaskingdifferentquestionstoit
- Goaboutitinasystematicfashion
- Tosolveaspecificproblem

This“skill”isakeyrequirementformanyanalysistypejobs.

CareerOptions:

Data Analytics #1: Students could get into any Analytics firm, and can assist customers in getting patterns outofdata.

Data Analytics #2: For Data Analytics in banks, there can be algorithms developed for fraud deduction usingthe digital imprints. This requires analyzing large amounts of data.That could a career choice - DigitalForensics.

Market Research: For doing a survey for customer expectations and behaviors, students utilize the data from onlineand offline channels to draw meaningful, actionable conclusions. For this the students need to use the various statisticalmethods which they learnt.So,MarketResearchin aMRfirmoracorporateentity canbealargeareaof focus.

Software Programmer: With analytical bent of mind, Students could take up a software

programming job. It mightnotleveragelearningbutwillleveragethe "bentof mind"cultivatedoutof the education. Students could focus on areas like: Visual Representation of Data (Tableau, Quilk, PowerBI), Data Reporting(CrystalReports)-that arealignedtothe coreskills.

Government Statistician: Our country requires a lot of econometric and statistical data for its running.Acreage, Yields, Health Statistics and the like. Bright young idealistic people are required to run our countrytoo. Students could be a District Statistical Officer, who is in charge of collecting information from the district,analyzing it andsharing withthe State Authorities.

Semester	Paper	Name of the paper	Subject code
	I	Statistical Inference	DSC I.3
III	II	Mathematical Programming	DSC II.3
	III	Linear and nonlinear modeling	DSC III.3
	IV	Operations Research	DSEI.3
		Bioassay	DSEII.3
		Econometrics	DSE III.3
		Actuarial Statistics	DSE IV.3
	LAB I	Practical I	DSCI.3, DSC II.3
	LAB II	Practical II	DSCIII.3, DSEI.3

Semester	Paper	Name of the paper	Subject code
IV	I	Computational Statistics	DSC I.4
	II	Multivariate Analysis	DSC II.4
	III	Stochastic Process	DSCIII.4
	IV	Baysian Inference	DSEII.4
		Statistical Ecology	DSE II.4
		Regression Analysis	DSE II.4
		Reliability Theory	DSE II.4
	Lab I	Practical I	DSC1.4, DSCII.4
	Lab II	Practical II	DSC III.4,DSE II.4

M.Sc.II (Statistics)(NEP Pattern) Semester III

DSC I.3 : Statistical Inference

Course Objective

The objective of estimation theory is to arrive at an estimator that exhibits optimality.

Toprovideasystematicaccount ofNeymanPearsontheoryoftestingand closelyrelatedtheoryof pointestimationandconfidencesets,togetherwiththeirapplications.

Course Outcome

Aftercompletingthiscourse, studentisexpected to learnthefollowing:

1Understandthevariousestimationand testingprocedurestodealwithreallifeproblems.

2Learn abouttheFisher Information,lowerboundstovarianceofestimators,MVUE.

3UnderstandtheconceptofNeyman-Pearsonfundamentallemma,UMPtestandintervalestimation.

4Understandtheconceptofcriticalregions,likelihoodratiotestwithitsasymptotic distribution.

Unit I : Criteriaofagoodestimator-unbiasedness,consistency,efficiency,sufficiency.Minimalsufficientstatistic.Exponential and Pitman families of distributions.Cramer-Raolower bound approach to obtain minimum variance unbiasedestimator. Uniformly minimum variance unbiased estimator,Completestatistic,Rao-Blackwelltheorem,Lehmann-Scheffe theorem.

Unit II : Method of moments, minimum chi-square estimation,maximumlikelihoodestimatoranditsproperties, CAN& BAN estimators.AncillarystatisticandBasu'stheorem.
Simpleandcompositehypothesis,conceptofcriticalregions,test functions, two types of error, power of the test, level ofsignificance,Neyman-Pearson lemma, uniformlymost powerful(UMP)tests.

Unit III : Types A, A1 critical regions, likelihood ratio test (LRT) withits asymptotic distribution, UMP tests for monotone likelihoodratiofamilyofdistributions.SimilartestswithNeymanstructure,Constructionofsimilaran dUMPUteststhrough
Neymanstructure.

Unit IV : Confidenceinterval,constructionofconfidenceintervalsusingpivotal,shortestexpectedlengthconfi denceinterval,uniformly most accurate one-sided confidence interval and itsrelationtoUMPtestforonesidednullagainstonesided alternativehypothesis.

Books Recomonded

1. Rohatgi,V.K.&Saleh,A.K.Md.E.(2015).AnIntroductiontoProbabilityandStatistics,3rdEdition. Wiley.
2. Lehmann,E.L.&Casella,G.(2014). TheoryofPoint Estimation,2nd Edition. Springer.
3. Lehmann,E.L.&Romano,J.P.(2010). TestingStatisticalHypotheses,3rd Edition. Springer.

Casella,G.& Berger,R.L. (2013). StatisticalInference, 2ndEdition. CengageLearning.

DSC II.3 : Mathematical Programming

Course Objectives:

Optimization techniques have application in almost all disciplines. To get on optimumsolution to the problem under given constraints is always challenging. To get the bestsolution to such problems, there are different methods depending on the problem andconstraints.Varioussuchproblemsandmethodsto solvethemarepart ofthiscourse.

Course Outcomes:

Attheend ofthecourse,studentsbecomewellversed with,

1. Toformulateandsolvelinearprogrammingproblem(LPP).Theyalsolearnvariousmethodstosolve LPP.ApplicationofLPPinindustry,management,transportation,assignment etc.
2. Sensitivity analysis of LPP by studying the effect of changes in coefficients ofconstraints on the solutions to the problem. They also learn the effect of any otherchangesintheconstraints,additionofnewconstraintonthesolutiontotheproblem.
3. Pure and mixed integer linear programming problem and formulation of nonlinearprogrammingproblemanddifferentmethodstosolve them.
4. Theproblemand differentmethodsofsolvingtwopersonzerosumgame.

Unit I :L. P. : Simplex method, variants of simplex method, duality in L. P. duality theorem,complementaryslacknesstheorem,dualsimplexmethod,transportation&assignmentproblems, method of solving transportation & assignment problems. Dynamic Programming :Dynamic programming approach for solvingoptimization problems, forward &

backwardrecursion formula,minimumpathproblem,single additive constraint&additivelyseparable

return,single multiplicativeconstraint&additivelyseparablereturn,singleadditiveconstraint&multiplicatively separable return,GoalProgramming.

Unit II :SensitivityanalysisofL. P.:Changes inR.H.S.constraintbi,changesincostcoefficientcj,changesin coefficientof constraintsaij,addition of newvariables,addition of newconstraints.I.L.P.P.: Pure & mixed I.L.P.P. , methods for solving pure & mixedI.L.P.P.Gomory'scuttingplanemethod,Branch&Boundtechnique.

Unit III : N.L.P.P.:GeneralN.L.P.P.,convex&concavefunctions,textforconcavity&convexity,localoptimum,globaloptimum,basicresultsforlocaloptimum&globaloptimum,Lagrange'smethods foroptimality, KT conditions, Q.P.P.Wolfe's&Beale's methodforsolvingQ.P.P.

Unit IV :

Gametheory:2personzerosumgame,pure&mixedstrategies,saddlepointofamatrixgame, matrix game without saddle point, methods for solving matrix game without saddlepoint,2X2,mxn,mx2,2Xnmatrixgames,dominanceprinciple,useofdominanceprincipleing ametheory, solving gameproblems bysimplex method.

Books Recomonded

1. S.M. Sinha : Mathematical Programming Theory and Methods Elsevier
2. Melvyn Jeter: Mathematical Programming An introduction to optimization Routledge Taylor and Francis group
3. N.S. Kambo: Mathematical Programming Technique East West Press Pvt Ltd.
4. R.K.Gupta : Linear Programming Krishna Prakashan

DSCIII.3 : Linear and Non linearModelling

Course Objectives:

Regression analysis is the most common statistical modelling approach used in dataanalysisanditisthe basisforadvancedstatisticalmodelling.

Theobjectiveofthiscourseistoimpartknowledgeabouttheusedifferentusefultoolsusedinregressionanalysis.Therelationshipbetweenvariablescanbeofdifferenttypeslike linear, nonlinear etc. The relationship is represented in terms of a model. Theadequacy of any model can be checked using residual plots and residual analysis.Appropriatestatisticaltoolsarerequiredtocheckfortheviolationsofmodelassumptionsandfordealingwithproblemsofmulticollinearityetc.

Course Outcomes:

At theend ofthecourse,studentsbecomewellversed with,

1. LinearandMultipleregression.
2. To interpret different types of plots such as residual plots, normal probability plotsetc. To check for the violations of model assumptions using residual analysis andotherstatisticaltests.
3. Todifferentiatebetweenlinearandnonlinearregressionundergivensituation.
4. GeneralizedLinearModelsincludinglogistic

Unit I : :MultipleLinearregression:Modelassumptionsandcheckingfortheviolationsofmodelassumption., Residual analysis – definition of residuals, standardized residuals, residual plots,statistical tests on residuals, Press statistics. Transformation of variables, Box-Cox powertransformation.Outliers : Detection and remedial measures, Influential observations : leverage, measures ofinfluence,Cook'sD,DFITSANDDFBETAS.

Unit II :Multicolinearity : Concept and definition of M.C., sources of M.C. consequences of M.C.identificationofM.C.usingthecorrelationmatrix,VIFremedialmeasures(collectingaddition aldata,modelrespecification,),conceptofridgeregression.Autocorrelation:consequences,Durbin -Watsontest,Estimationofparametersinthepresenceofautocorrelation.

Unit III : Variableselection:Problemofvariableselection,criteriaforevaluationsubset regressionmodels(choosingsubsets),coefficientofmultipledetermination,residualmeansquare, Mallow's Cp Statistics. Computational Techniques for variable selection-Forward selection,Backwardelimination,stepwise regression.
Non-linearregression:DifferencebetweenLinearandNon-LinearRegressionModels,transformationtoalinearmodel,Intrinsicallylinearandnon-linearmodels.ParameterestimationusingtheNewton-Gaussmethod,Hypothesistesting.

Unit IV :Generalized linear models : Exponential families, Definition of GLM, Link function,Estimation of parameters and inference in GLM. Logistic regression model : Link function,logit, probit, complementary log-log, estimation of parameters, odds ratio, hypothesis testingusingmodeldeviance.

Books recomonded

1. Jean Gomes : Leading in nonlinear world : Building Wellbeing, strategic and innovation mindsets for the future
2. S. Nanda : Nonlinear Analysis
3. Steen Krenk: Non linearModelling Cambridge
4. Giuseppe Lancia, Paolo Serafini : Compact Extended Linear Programming Models springer

DSEI.3: Operations Research

Course Objectives:

Operations research deals with the application of advanced analytical methods whichhelpsintakingbetterdecisions.Thecourseincludesadvancedtechniquesthatareusefulinbusiness, management,industry,projectplanningetc.

Course Outcomes:

At theend ofthecourse,studentsbecomewellversed with,

1. Conceptofinventoryproblem,needofinventoryandtypesofinventorymodelsandtypes ofprobabilisticinventorymodels.
2. Sequencingproblemsandmethodstosolvesequencingproblemsindifferentsituations
3. Conceptofqueues,differenttypesofqueuesand their analysis.
4. ConceptofNetworking,CPM,PERTandmethodsofobtainingoptimumsolutionstotheproblems.

Unit I : **Inventory problems** : Structure of inventory problem, EOQ formula, EOQ model withuniform rate of demand & having no shortages, EOQ model withdifferent rate of demand indifferentcycleshavingnoshortages,EOQmodelwithuniformrateofdemand &finiterateofreplenishment having no shortages,EOQ model with uniform rate of demand & finite rate ofreplenishment having shortages, EOQ model with uniform rate of demand, infinite rate ofreplenishmenthaving shortages,EOQmodelwithsingle&doubleprice breaks.

Unit II : Singleperiodprobabilistic inventorymodelswith

i) instantaneousdemand&discreteunits
ii) instantaneousdemand&continuousunits
iii) Continuousdemand&discreteunits
iv) Continuousdemand&continuousunits

Unit III : Processing n jobs through twomachines,

Processingnjobsthroughthreemachines,

Processing 2 jobs through m machines,

Processing n jobs through m machines,

Travelingsalesmanproblem

Queuing Models:M/M/1 :FCFS/ / &itsgeneralization

M/M/1:FCFs/N/M/M/C/□ ,

FCFS/M/Ek/1: FCFS/ □ / □,

| | /| | ,

Unit IV : Networking : Basic steps in PERT & CPM, methods of solving PERTproblem, crashingthe network, updating (PERT & CPM) max. flow min. cut theorem, problems based on max.flowmin.cuttheorem.

Books Recomonded

1. S. Kalavathy : Operations Research Vikas Publications
2. Frederick S. Hillier : An introduction to Operations Research McGraw Hill
3. Kantiswaroop, P. K. Gupta, Man Mohan : Operations Research Sultan Chand & Sons
4. SheikhAhmedHossain, SamarjitKar : Operations Research Recent Advances Narosa Publishing House

DSE II.3 : Bioassay

Course Objectives:

Bioassayisananalyticalmethodtodetermineconcentrationofa substancebyitseffectonlivingcells,tissues, insects,etc.Therearevarioustypesof Bioassayslikequalitativeorquantitative,directorindirect.Thesean alyticalmethodsareusefulinenvironmentalscience,microbiologyetc.Themethodofdoseandresponser elationshipinthisanalysisis used in pharmaceutical sciences. Objective of this course is to train students inanalyticalmethods usedinthesefields.

Course Outcomes:

At theend ofthecourse,studentsbecomewellversed with,

1. Typesofbiologicalassaysandmethods forestimatingdoseresponserelationship.
2. Logit andprobit approachforestimatingdose-responserelationship.
3. Methodsofestimationofparametersand doseallocationschemes.
4. Sequentialprocedures,estimationofsafedose,ANOVAandBayesianapproachtoBioassays.

Unit I : Types of biological assays, Direct assays, ratio estimators, asymptotic distributions,Fieller'stheorem.Regressionapproachestoestimatingdose-responserelationships,LogitandProbitapproacheswhendose-response curveforstandard preparation isunknown.

Unit II : Methods of estimation of parameters, estimation of extreme quantiles., dose allocationschemes.Quantal Responses,Polychotomousquantalresponses.estimation of points on thequantalresponsefunction

Unit III : Sequentialprocedures, estimationofsafedoses.

Unit IV : ANOVAandBayesianapproachtoBioassay

Books Recomonded

1. R.C. Dubey : Advanced Biotechnology S. Chand
2. S.J. Amdekar : Statistical Methods for Agricultural and Biological sciences
3. P.K. Bajpai : Biological instrumentation and Methodology S. Chand & Company
4. Thieman : Introduction to Biotechnology Pearson

DSE III.3 : Econometrics

Course Objective

Thepurposeof thiscourseistogive studentsa solidfoundation ineconometrictechniques,variousfunctions for economicanalysisand futureforecasting.

Course Outcomes

Oncompletionofthis course, studentswillbeableto:

1:Understandthebasicconceptsofeconometricmodels.

2:Learnknowledgeofvariouseconometricmodels,estimationmethodsandrelatedeconometrictheories.

3:Understandthestatisticaltechniquestomodelrelationshipsbetweenvariablesandmakepredictions.

4:Learnhowto conducteconometricanalysisofdata.

Unit I : Introduction to econometrics. A review of least squares and maximumlikelihood estimation methods of parameters in classical linear regressionmodelandtheirproperties.Generalizedleastsquaresestimationandprediction, construction of confidence regions and tests of hypotheses.Regressionanalysisunderlinearrestrictions,restrictedleastsquaresestimationmethodanditsproperties.Autocorrelation,sourcesandconsequences,Autoregressiveprocesstestsforautocorrelation,Durbin Watsontest.

Unit II :ProblemofMulticollinearity,itsimplications.Sourceofmulticollinearity,toolsforhandlingtheproblemofmulticollinearity.Remediesformulticollinearity.Ridgeregression.Heteroskedasticity,consequences and tests for it, estimation procedures under heteroskedasticdisturbances,Bartlett'stest,BreuschPagantestand GoldfelfQuandttest.DummyVariableModels.

Unit III : SpecificationErrorAnalysis,TestsforStructuralChangeandStability, Asymptotictheoryandregressors.Stein-RuleEstimation.Instrumentalvariableestimation.Measurement Error Models.

Unit IV : Simultaneous equations model, problem of identification, necessary andsufficient condition for the identifiability of parameters in a structuralequation,ordinaryleastsquares,indirectleastsquares,two-stageleast squaresandlimitedinformationmaximumlikelihoodmethod.

Books Recomonded

1. Gujrati,D.N.&Porter,D.C.(2017).BasicEconometrics,6th Edition.McGrawHill.
2. Maddala,G.S. &Lahiri, K.(2010).IntroductiontoEconometrics,4thEdition.Wiley.
3. Greene,W.H.(2012).EconometricAnalysis,7th Edition.Pearson.

Studenmund,A.H.&Johnson,B.K. (2017).UsingEconometrics: APractical Guide,7thEdition.Pearson.

DSE IV.3: Actuarial Statistics

Course Objectives:

Actuarial science includes statistical methods to assess risk mainly in insurance andfinance. The course includes these statistical methods based on probability theory andstochastic models. Objective here is to make the students aware about this importantbranchofstatistics.

Course Outcomes:

At theend ofthecourse,studentsbecomewellversed with,

1. Conceptofinventoryproblem,needofinventoryandtypesofinventorymodelsandtypes ofprobabilisticinventorymodels.
2. Sequencingproblemsandmethodstosolvesequencingproblemsindifferentsituations
3. Conceptofqueues,differenttypesofqueuesand their analysis.
4. ConceptofNetworking,CPM,PERTandmethodsofobtainingoptimumsolutionstotheproblems.

Unit I : Life table and its relation with survival function, assumptions for fractional ages, someanalytical laws of mortality, select and ultimate tables. Multiple life functions, joint and lastsurvivorstatus,insuranceandannuitybenefitsthrough multiplelifefunctions.Multipledecrement models, deterministic and random survivor groups, associated single decrementtables,centralratesofmultipledecrement,netsinglepremiumsandtheirnumericalevaluations.

Unit II : Principalsofcompoundinterest:Nominalandeffectiveratesofinterestanddiscount,forceofinterestanddiscount ,compoundinterest,accumulationfactor,continuouscompounding.Life insurance : Insurance payable at the moment of death and at the end of theyear of death-level benefit insurance, endowment insurance, deferred insurance and varyingbenefitinsurance,recursion,commutationfunctions.

Unit III : Life annuities : Single payment, continuous life annuities, discrete life annuities, lifeannuitieswithmonthlypayments,commutationfunctions,varyingannuities,recursion,complete annuities-immediate and apportionableannuities-due. Net premiums : Continuousanddiscretepremiums,truemonthlypaymentspremiums,apportionablepremiums,commutationfu nctions,accumulationtypebenefits.

Unit IV: Netpremium reserves:Continuousanddiscrete netpremium reserveson a semicontinuous basis, reserves based on true monthly premiums, reserves on an apportionable ordiscountedcontinuousbasis,reservesatfractionalduration,allocationsoflosstopolicyyears,recursiveformul as and differential equationsfor reserves, commutation functions. Somepracticalconsiderations:Premiumsthatincludeexpenses–generalexpenses,typesofexpenses, per policy expenses. Claim amount distributions, approximating the individualmodel,stop-lossinsurance.

Books Recomonded

1. Shailaja R. Deshmukh : Actuarial Statistics An introduction Universities Press (India)
2. Dale S. Borowiak, Arnold F Shapiro : Financial and Actuarial Statistics Chapman and Hall
3. P. S. Waldhe : Actuarial Statistics NiraliPrakashan
4. Swiss Re : Statistical foundations of Actuarial Learning and its applications Springer

LABI :Practicals Based on DSCI.3 and DSCII.3

LABII :Practicals Based on DSCIII.3 and DSEI.3

M.Sc. II (Statistics)(NEP Pattern) SIV

DSCI.4: Computational Statistics

Course Objectives:

Inmanydisciplines,resultsareestablishedwiththehelpofthedatabyfittingasuitablemodel . Analyzing the data plays an important role in such cases. Advanced statisticalmethodsanddifferenttypesofmodelscanbeappliedtothese data,evenverybigdata.The course deals with different computational methods and algorithms necessary foranalysis of the data. The course includes different methods that are particularly usefulin simulating data from various distributions and analyzing them with the help ofcomputers.

Course Outcomes:

At theend ofthecourse,studentsbecomewellversed with,

1. Visualizationofdata and exploratorydata analysis.
2. StochasticsimulationtechniqueslikeMCMC.
3. Someimportantmethodsofhandlingmissingdataandincompletedataproblemslike EM algorithmetc.
4. Jackknife,Bootstarpandnonparametricdensityestimationusingkernels.

Unit I :Exploratorydataanalysis:ComponentsofEDA,transformingdata,Clustering:Similaritymeasures,similarity coefficients,Heirarchical clusteringmethods:single,completeandaveragelinkagemethods,dendrograms.GraphicalMethods:Quintilepl ots,BoxPlots,Histogram,Stem&leafdiagram,Q-Qplots,P-Pplots

Unit II : Stochasticsimulation:generatingrandomvariablesfromdiscreteandcontinuousdistributions, simulation bivariate/multivariate distributions, simulating stochastic processessuchassimplequeues.Variancereductiontechnique:Importancesamplingforintegration, control variates, antithetic variables.MCMC methods : Essence of MCMC methods, TimereversibleMC,LawoflargenumbersforMC.Metropolis-Hastingsalgorithm,Gibbssamplingforbivariate/multivariate simulation. Simulatedannealingforoptimization,simulatedannealingforM.C.Simulationbasedtesting:simulating test statisticsand powerfunctions,permutation/randomizationtests.

Unit III : Resamplingparadigms:JackknifeandBootstrap:DeleteoneJ-K,pseudovalues,Biasand S.E. Efron's bootstrap, Bootstrap C.I. Bootstrap-t C.I, Bootstrap C.I. (percentile

method),Bootstrapinregression,BootstrapC.I.forlinearregressionparameters.

Unit IV :EM algorithm: Application to missing and incomplete data problems. Mixture models.Smoothing with Kernels: Density estimation, kernel density estimator for univariate data,Bandwidthselectionand crossvalidation,Maxlikelihood LCV,LeastsquareCV.

Books Recomonded

1. J. E. Gentle, W. K. Hardle, Y. Mori : Computational Statistics Concepts and Methods Springer
2. G.H. Givens,J.A. Hoeting : Computational Statistics Wiley
3. J.E. Gentle : Statistics and Computing Springer
4. R.L. Ruiz : Computational Statistics and Applications
5. MarepalliRao, C.R.Rao : Computational Statistics with R Elsevier

M.Sc. II (Statistics)(NEP Pattern) SIV

DSCII.4 : Multivariate Analysis

Course Objective

Themain objectiveof thiscourseisto introducestudents tothe analysisofobservationsonseveral correlated random variables for a number of individuals. Multivariate analysis isapplicablein almostall scientificstudies, for examplein Anthropology,Lifesciences, AgricultureandEconomics, whenonedeals withseveralvariables simultaneously.

Course Outcome

Aftercompletingthiscourse, studentisexpected to learnthefollowing:

1Accountforimportanttheoremsandconceptsinmultivariateanalysis.

2Understand the concept ofWishart andHotelling'sT^2distribution.

3Understandthelinkbetweenmultivariatetechniquesandcorrespondingunivariatetechniques.

4Conductstatisticalinferenceaboutmultivariatemeansincludinghypothesistesting, confidenceregion calculation,etc

Unit I : Multivariatenormaldistribution,itspropertiesandcharacterization. Random sampling from a multivariate normaldistribution.Maximumlikelihoodestimatorsofparameters.Distribution of sample mean vector. Inference concerning themeanvectorwhenthecovariancematrixisknown.Matrix normaldistribution.Multivariatecentrallimittheorem.

Unit II :Wishartmatrix,itsdistributionandproperties.Distributionof samplegeneralizedvariance.Hotelling'sT^2statisticandits distributionandproperties.Applicationsintestsonmeanvectorforoneandmoremultivariatenormalpopulations. Mahalanobis'D^2.

Unit III : Likelihood ratio test criteria for testing of independence of setsofvariables,equalityofcovariancematrices,identityofseveralmultivariatenormalpopulations,equalityofac ovariancematrixtoagivenmatrix,equalityofameanvector andacovariancematrixtoa givenvector and a givenmatrix

Unit IV : Classification and discrimination procedures fordiscriminationbetweentwomultivariatenormalpopulations,sample discriminant function, tests associated withdiscriminantfunctions,classificationintomorethantwomultivariate normal populations.Principal

components,canonicalvariablesandcanonicalcorrelations.Multivariateanalysisofvariance[MANOVA]ofone-wayclassifieddata.Wilk'slambdacriterion.

Books Recomonded

1. Johnson,R.A.andWichern,D.W.(2015):AppliedMultivariateStatisticalAnalysis,SixthEdition,PearsonEducationIndia.
2. Hardle,W.K.andHlavka,Z.(2015):Multivariate Statistics,Springer.
3. Anderson,T.W.(2003):An IntroductiontoMultivariateStatisticalAnalysis,ThirdEdition,Wiley.
4. Härdle,W.K.andSimar, L.(2015):AppliedMultivariateStatisticalAnalysis,Springer.

Singh,B.M.(2004):Multivariatestatisticalanalysis,SouthAsianPublishers.

M.Sc. II (Statistics)(NEP Pattern) SIV

DSCIII.4 : Stochastic Process

Course Objective

Theobjectiveof this courseis to apprisethe students with thebasic concepts of thetheoryofstochasticprocesses incontinuoustime,alsoto makethemabletousevarious analyticaland computational techniques to studystochasticmodels that appears in applications.

Course Outcomes

Aftercompletingthiscourse, studentisexpected to learnthefollowing:

1Studythe fundamentalconcept ofstochasticprocesses and itsapplications.

2UnderstandMarkovprocesses andMarkov chainsandtheirapplicationsinrealworld.

3Studythe branchingprocess and its properties.

4UnderstandPoissonprocesses anditsvariations.

Unit I : Stochastic Processes: Introduction, classification accordingtostate space and time domain. Countable state Markov chains,transition probability matrix, Chapman-Kolmogorov equations,calculationofn-steptransitionprobabilitiesandtheirlimits, stationarydistribution.

Unit II : BranchingProcesses:Propertiesofgeneratingfunctionofbranchingprocesses,probabilityofultimateextinction, distribution of the total number of progeny, generalization of theclassicalGalton-Watsonbranchingprocess,generalbranching processes,randomwalk andgambler's ruinproblem.

Unit III : Continuous-time Markov Processes: Poisson process and relateddistributions, generalizations of Poisson process, simple birth-process,simpledeath-process,simplebirth-deathprocess,linear birth-deathprocess.Firstpassagetime distribution.

Unit IV : Renewal Theory: Elementary renewal theorem and applications.Statementandusesofkeyrenewaltheorem,centrallimittheorem for renewals, study of residual and excess lifetime'sprocess.RenewalrewardProcess,Markovrenewalandsemi-Markovprocesses,Markovrenewalequations.

Books Recomonded

1. Medhi,J.(2012).StochasticProcesses,3rdEdition.NewAgeInternational.
2. Ross,S.M.(2016). StochasticProcesses,2ndEdition.WileyIndia.

3. Karlin,S.&Taylor, H.M. (2012).A FirstCourseinStochasticProcesses, 2nd Edition. AcademicPress.
4. Prabhu,N.U.(2010).StochasticProcesses:Basic TheoryanditsApplications. WorldScientific.

M.Sc. II (Statistics)(NEP Pattern) SIV

DSEI.4: Baysian Inference

Course Objective

The objective of this courseis toprovide theunderstanding of the decision theory andfundamentalsofBayesianinferenceincludingconceptofsubjectivityandpriorsbyexamining somesimpleBayesianframework.

Course Outcomes

Aftersuccessfulcompletionofthiscourse,student willbe ableto:

1. Tounderstand and utilize pastexperience alongwith presentobservation andimprovethe inferences.
2. Equipstudentswithskillstocarryoutandinterpretposteriordata-basedmodelingandanalyses.
3. UnderstandDecisiontheoreticalconcepts,gametheoryandtheirapplications.
4. TounderstandtheBayesianestimationandtestingproceduresandcomparethemwithclassic alinference.

Unit I : Bayes Rule, extended Bayes rule, Minimax rule,methodsforfindingminimaxrules,Generalized bayes and limit of bayes rule, Concept of admissibility and completeness Bayesrules, Admissibility of Bayes and minimax rules, Supporting and separating hyper planetheorems,complete classtheorem,MinimaxestimatorsofNormalandPoissonmeans.

Unit II : Subjective interpretation of probability in terms of fair odds, Evaluation of (i) subjectiveprobabilityofaneventusingasubjectivelyunbiasedcoin(ii)subjectivepriordistributio nofa parameter, Bayes theorem and computation of the posterior distribution, Natural Conjugatefamilyofpriorsfora model,Hyperparametersofapriorfromconjugatefamily

Unit III : Bayesianpointestimationasapredictionproblemfromposteriordistribution,Bayesestimators for (i) absolute error loss (ii) squared error loss (iii) 0 -1 loss, Bayesian intervalestimation:credibleintervals,Highestposteriordensityregions

Unit IV : Interpretationoftheconfidencecoefficientofanintervalanditscomparisonwiththeinterpretation of theconfidencecoefficientforaclassicalconfidenceinterval,BayesianTesting Hypothesis: Specification of the appropriatefrom of the prior distribution for aBayesiantestingofhypothesisproblem,Priorodds,Posteriorodds,Bayesfactor.

Books Recomonded

1. JamesOBerger (1985):StatisticalDecisionTheoryandBayesiananalysis. Springer.
2. FergusionT.S.(1967):MathematicalStatistics-
   AdecisionstheoreticApproach.Academic Press.
3. DeGroot. M.H. :OptimalStatisticalDecisions. McGrawHill.
4. LeonardT andHsuJ.S.J.:BayesianMethods. CambridgeUniversityPress.
5. Bernardo,J.M.andSmithAFM:BayesianTheory. JohnWilley.
6. Rao,C. R.(1973):LinearStatisticalInferenceanditsApplications,WileyEastern.
7. Robert,C.P.:TheBayesianChoice:ADecisionTheoreticMotivation,Springe

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DSEII.4 : Statistical Ecology

Course Objectives:

Ecologyisstudyofinteractionoforganismsthatincludebioticandabioticcomponentsand their environment. Ecologists can explain life processes, interactions, adoptions,movement of materials, distribution of organisms, biodiversity etc. by using variousstatistical methods. The course gives knowledge of these methods and models in thisparticularbranch.

Course Outcomes:

At theend ofthecourse,studentsbecomewellversed with,

1. Conceptofinventoryproblem,needofinventoryandtypesofinventorymodelsandtypes ofprobabilisticinventorymodels.
2. Sequencingproblemsandmethodstosolvesequencingproblemsindifferentsituations
3. Conceptofqueues,differenttypesofqueuesand their analysis.
4. ConceptofNetworking,CPM,PERTandmethodsofobtainingoptimumsolutionstothe problems.

Unit I : Population Dynamics One species exponential, logistic and Gompertz models,.Twospeciescompetition,coexistence,predatorpreyoscillation,Lotka-VolterraEquations,isoclines, Lestie matrix model for age structured populations. Survivorship curves constanthazardrate,monotonehazardrateandbathtubshapedhazardrates

Unit II : Population density estimation: Capture recapture models, nearest neighbor models, Linetransectsampling,EcologicalDiversin,Simpsonsindex,Diversityasaverageraity

Unit III : Optimal Harvesting of Natural Resources, Maximum Sustainable field, tragedy of thecommons Game theory in ecology, concepts of Evolutionarily stable strategy, its Properties,simple cases suchas Hawk-Dovegeme.

Unit IV : ForagingTheory:DietchoiceProblem,patchchoiceproblemmeanvariancetradeoff.

Books Recomonded

1. L.J. Young , J. H. Young : Statistical Ecology Springer

2. D.I. Warton : Data analysis in Ecology Springer

3. A. P. Robinson , S.T. Buckland, P. Reich M. McCarthy : Methods in statistical Ecology Springer

4. G. Guillot, A. Arab, J. B. Illian, S Dray : Advances in statistical Ecology

DSEIII.4: Regression Analysis

Course Objective

Theobjectivesof thiscourseareto developtheoretical foundationofregressionmodelsandunderstandfundamentalconcepts of regression analysis.

Course Outcome

Oncompletionofthiscourse, studentswillbeableto:

1Understandsimple andmultiplelinearregressionmodelswiththeirapplications.

2 Learnthefittingof thesemodels tosimulatedandrealdatasets.

3Learnmodeladequacyusingclassicaldiagnostics,awarenessofpotentialproblems(outliers,etc.)and application ofremedies to dealwith them.

4Understandthebasicconceptsoflogistic,Poissonandgeneralizedlinearmodels.

Unit I : Simple Linear Regression: Simple linear regression model. Least-squaresestimation of parameters.Hypothesis testing on the slope and intercept.Intervalestimationinsimplelinearregression.Predictionofnewobservations.Coefficiento fdetermination.Estimationbymaximumlikelihood. Multiple linear regression: Multiple linear regression models.Estimation of the model parameters. Hypothesis testing in multiple linearregression.Confidenceintervalsinmultipleregression.Coefficientof determinationand Adjusted R^2.

Unit II : Model Adequacy: Checking of linearity between study and explanatoryvariable, Residual Analysis, Detection and treatment of outliers, Residualplots. The PRESS statistic.Outlier test based on Studentized Residual (R-student). Test for lack of fit of the regression model. Transformation andWeightingtoCorrectModelInadequacies:Variancestabilizingtransformations.Transformation stolinearizethemodel.Analytical methodsforselectingatransformationonstudyvariable.

Unit III : Generalizedandweightedleastsquareestimation.PolynomialRegressionModels:Polynomialmode lsinonevariable.OrthogonalPolynomials.Piecewisepolynomial(Splines).VariableSelectionandM

odelBuilding:Incorrectmodelspecifications.Evaluationofsubset regressionmodel.Computationaltechniquesforvariableselection.

Unit IV : Logistic and Poisson regression models: Introduction, Linear predictorandlinkfunctions,logit,probit,oddsratio,maximumlikelihoodestimation, test of hypothesis. Generalized linear models: Exponentialfamily of distribution, Linear predictors and link functions, MaximumlikelihoodestimationofGLM.Predictionandconfidenceintervalwith GLM.

Books Recomonded

1. Montegomery,D.C.,Peck,E.A.&Vining,G.G.(2015).IntroductiontoLinearRegressionAnalysis,5th Edition.Wiley.
2. Rao,C.R.(2009).LinearStatisticalInferenceanditsApplications,2nd Edition.Wiley.
3. Draper,N.R.&Smith,H.(2011).AppliedRegressionAnalysis,3rd Edition.Wiley.
4. Chatterjee, S.andHadi,A.S.(2012).RegressionAnalysisbyExample,5th Edition.Wiley.

Fox,J.andWeisberg,S.(2019).AnRCompanionto AppliedRegression,3rd Edition.SagePublications

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DSE IV.4 : Reliability Theory

Course Objectives:

Manmadesystemssufferfromimperfectionsforseveralreasons.Oftentheseimperfections leadto improper functioning resulting infailure of the systemIt maybe the result of defect in the system while producing it or may be because of naturalcomponent deterioration on some interacting factors. Probability of non failure istermed as reliability. Reliability models can be developed for predicting the reliabilityofacomponentorofsystempriortoitsimplementation.

Course Outcomes:

At theend ofthecourse,studentsbecomewellversed with,

1. Failuretimedistribution,reliabilityfunction,hazardfunctionetc.
2. Increasingfailurerateasaneffectofageing, shockmodels.
3. Reliabilityestimationinvariouscases.
4. Reliabilitygrowthmodels.

Unit I : Reliability concepts and measures ,components and systems, coherent systems, reliabilityof coherent systems, cuts and paths, modular compositions, bounds on system reliability,structural and reliability importance of components. Life distributions, reliability functions,hazardrate,commonlifedistributions,exponential,Gamma,Weibull,Lognormaletc.Est imationofparameters, confidenceintervals,LRandMLEtestsforthesedistributions.

Unit II : Notions of ageing: IFR, IFRA, NBU, DMRL and NBUE classes and their duals, loss ofmemory property of the exponential distribution, closures of these classes under formation ofcoherentsystems,convolutionsandmixtures.Univariateshockmodelsandlifedistributions arisingoutofthem,bivariateshockmodel,commonbivariateexponentialdistributionsandtheirpropert

ies.

Unit III : Reliability estimation based on failure times in variously censoredlife tests and in testswith replacement of failed items, stress and strength reliability and its estimation. aintenanceand replacement policies, availability of repairable systems, modeling of repairable system bya non-homogeneous Poissonprocess

Unit IV : Reliability growth models,probability plottingtechniques,Hollander-Proschan andDeshpandetestsforexponentially,testsforHPPvs.NHPP withrepairablesystems.

Books Recomonded

1. M. Rausand, A. Barros, A Hoyland : System Reliability Theory Wiley
2. I. Bazovsky : Reliability Theory and Practice Dover Publications
3. J. Navarro: Introduction to system Reliability Theory Springer
4. B.V. Gnedenko : Mathematical methods of reliability theory Academic Press

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LAB I : PracticalbasedonDSCI.4&DSC II.4

LAB II - PracticalbasedonDSC III.4&DSE I.4