Sant Gadge Baba Amravati University, Amravati

Faculty of Science and Technology Programme: **M.Sc. II (SEM III & SEM IV) Statistics**

Program Outcomes (POs)

At the end of the Programme, students would be able to
PO1: **Critical Thinking**: Think critically for data driven solution with advanced Methodology. Students may be able to think critically everything around him/her. They will be able to take better action in any critical situation in their life.

PO2: Nurture their curious minds toward translation and application & Statistical knowledge to find solutions to real world problems.

PO3: **Employability: Get** knowledge and skills in depth necessary for employability of students in industry, Govt Sector and organizations as well as in academics.

PO4: **Empowerment**: Be empowered to investigate, solve questions for which answer lies beyond the boundaries of conventional thinking.

PO5: **Effective decision making**: Take proper decision in critical and complicated situations. Reduce risk factor and be able to maximize project.

PO6: **Effective citizenship**: Get acquainted with the needs of the industry and society, and they become the assets for the society.

PO7: **Social interaction**: Develop sensitivity for social issues and become productive citizen of the nation.

Program Specific outcomes (PSOs)
Upon completion of the Programme successfully, students would be able to

PSO1: Understand basic theoretical and applied principles of Statistics needed to enter the job force. They will be able to communicate key statistical concepts to non-statisticians. They also gain proficiency in using statistical ideas/principles for data analysis.

PSO2: Groom as the next generation statisticians ready for scientific decision making, aided with advanced statistical software translating into sharp and extensive analytics pertinent to various domains.

PSO3: Start consultancy for statistical analysis and can be helpful in interdisciplinary research.

PSO4: Perform Statistical quality control, which is the most important sector of any industry where students can work as statisticians to approve the quality.

Employability Potential of the Programme

The Programme offers many opportunities, where statistician can work. By completing this programme, students are able to:

- Analyze the things
- Understand patterns in them by asking different questions to it
- Compete with the current demand of field.
- To solve a specific problem

This“skill”is a key requirement for many analysis type jobs like,

1. Statisticians
2. Business Analyst
3. Mathematician
4. Professor
5. Risk Analyst
6. Data Analyst
7. Content Analyst
8. Statistic Trainer

Besides all these students can work in various banking sector. Students can also work in government sector:

- Indian statistical services(ISS)
- Staff Selection Services(SSC)
- Reserve Bank of India (Junior statistical officer)

By taking the programme, students are able to:

- Analyze numbers
- Understand patterns in them by asking different questions to it
- Go about it in a systematic fashion.
- To solve a specific problem.

This “skill” is a key requirement for many analysis type jobs.

Career Options:

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

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

Market Research: For doing a survey for customer expectations and behaviors, students utilize the data from online and offline channels to draw meaningful, actionable conclusions. For this the students need to use the various statistical methods which they learnt. So, Market Research in a MR firm or a corporate entity can be a large area of focus.

Software Programmer: With analytical bent of mind, Students could take up a software programming job. It might not leverage learning but will leverage the "bent of mind" cultivated out of the education. Students could focus on areas like: Visual Representation of Data (Tableau, Quilk, and PowerBI), Data Reporting (Crystal Reports)-that are aligned to the cores kills.

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 country too. Students could be a District Statistical Officer, who is in charge of collecting information from the district, analyzing it and sharing with the State Authorities.

Semester	Paper	Name of the paper	Subject code	Total Credits
III	I	Statistical Inference	DSCVII (Sts-8)	4
	AEC on DSC VII	Performing inference including statistical modeling, data oriented strategies		2
	II	Mathematical Programming	DSC VIII (Sts-9)	4
	III	Linear and nonlinear modeling	DSC IX (Sts-10)	4
	IV	Operations Research	DSEIIIA (Sts-11)	4
		Bioassay	DSEIII B(Sts-12)	4
		Econometrics	DSE III C(Sts-13)	4
		Actuarial Statistics	DSE IIID(Sts-14)	4
	LAB I	Practical I	DSCP1	2
	LAB II	Practical II	DSCEP2	2
			Total Credits	26

Semester IV	Paper I	Name of the paper Computational Statistics	Subject code DSC X (Sts-15)	4
	AEC on DSCX	Application on Monte Carlo methods		2
	II	Multivariate Analysis	DSC XI (Sts-16)	4
	III	Stochastic Process	DSC XII (Sts-17)	4
	IV	Bayesian Inference	DSEIV A (Sts-18)	4
		Statistical Ecology	DSE IV B (Sts-19)	4
		Regression Analysis	DSE IV C(Sts-20)	4
		Reliability Theory	DSE IV D(Sts-21)	4
	LAB I	Practical I	DSCP1	2
	LAB II	Practical II	DSCEP2	2
			Total Credits	26

M.Sc. (Statistics) Semester III

DSC VII (STS -8): Statistical Inference

Course Objective

The objective of estimation theory is to arrive at an estimator that exhibits optimality. To provide easy stematic account of Neymann Pearson theory of testing and closely related theory of Point estimation and confidence sets, together with their applications.

Course Outcome

After completing this course, student is expected to learn the following:

1 Understand the various estimation and testing procedures to deal with real life problems.

2 Learn about the Fisher Information, lower bounds to variance of estimators, MVUE.

3 Understand the concept of Neymann- Pearson fundamental lemma, UMP test and interval estimation .

4 Understand the concept to critical regions, likelihood ratio test with its asymptotic Distribution.

Unit I: Criteria of a good estimator-Unbiasedness, consistency efficiency, sufficiency .Minimal sufficient statistic. Exponential and Pitman families of distributions. Cramer-Rao lower bound approach to obtain minimum variance unbiased estimator. Uniformly minimum variance unbiased estimator, Complete statistic, Rao-Blackwell theorem, Lehmann-Scheffe theorem.

Unit II : Method of moments, minimum chi-square Estimation, maximum likelihood estimator and its properties, CAN& BAN estimators. Ancillary statistic and Basu's theorem. Simple and composite hypothesis, concept to critical regions, test functions, two types of error, power of the test, level of significance, Neymann-Pearson lemma, uniformly most powerful(UMP)tests.

Unit III :

Types A, A1 critical regions, likelihood ratio test (LRT) with its asymptotic distribution, UMP test for monotone likelihood ratio family of distributions. Similar tests with Neymann structure, Construction of similar and UMPU tests through Neyman structure.

Unit IV : Confidence interval, construction of confidence intervals using pivotal, shortest expected length confidence interval, uniformly most accurate one-sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypothesis.

Books Recommended

1. Rohatgi, V.K. & Saleh, A.K.Md.E. (2015).An Introduction to Probability and Statistics, 3rdEdition. Wiley.
2. Lehmann, E.L. & Casella. (2014). Theory of Point Estimation,2nd Edition. Springer.
3. Lehmann, E.L. & Romano, J.P. (2010). Testing Statistical Hypotheses,3rd Edition. Springer.
Casella. & Berger .L. (2013). Statistical Inference, 2ndEdition. CengageL earning.

AEC on DSC VII

Performing inference including statistical modeling, data oriented strategies

Syllabus

Understand the process of drawing conclusion about populations or scientific truths from data, Describe variability, distributions, limits and confidence intervals, Make informed data analysis decisions

DSC VIII (STS-9): Mathematical Programming

Course Objectives:

Optimization techniques have application in almost all disciplines. To get on optimum solution to the problem under given constraints is always challenging. To get the best solution to such problems, there are different methods depending on the problem and constraints. Various such problems and methods to solve them are part of this course.

Course Outcomes:

At the end of the course, students become well versed with,

1. To formulate and solve linear programming problem (LPP). They also learn various methods to solve LPP .Application of LPP in industry, management, transportation, assignment etc.
2. Sensitivity analysis of LPP by studying the effect of changes in coefficients of constraints on the solutions to the problem. They also learn the effect of any other changes in the constraints, addition of new constraint on the solution to the problem.
3. Pure and mixed integer linear programming problem and formulation of nonlinear programming problem and different methods to solve them.
4. The problem and different methods of solving two person zero sum game.

Unit I :L. P. : Simplex method, variants of simplex method, duality in L. P. duality theorem, complementary slackness theorem, dual simplex method ,transportation & assignment problems, method of solving transportation & assignment problems. Dynamic Programming :Dynamic programming approach for solving optimization problems, forward & backward recursion formula, minimum path problem ,single additive constraint & additively separable

return, single multiplicative constraint & additively separable return, single additive constraint & multiplicatively separable return, Goal Programming.

Unit II

: Sensitivity analysis of LP Changes in R.H.S .constraint bi, changes in cost coefficient cj, changes in coefficient of constraints aij, addition of new variables, addition of new constraints. I.L.P.P.: Pure & mixed I.L.P.P., methods for solving pure & mixed I.L.P.P. Gomory's cutting plane method, Branch & Bound

technique.

Unit III : N.L.P.P: General N.L.P.P. ,convex & concave functions, text for concavity & convexity, local optimum, global optimum, basic results for local optimum & global optimum, Lagrange's methods for optimality, KT conditions, Q.P.P. Wolfe's & Beale's method for solving Q.P.P.

Unit IV : Game Theory: Two person zero sum game, pure & mixed strategies, saddle point of a matrix game, matrix game without saddle point, methods for solving matrix game without saddle point, 2 x 2, m x n, m x 2, 2 x n matrix games, dominance principle, use of dominance principle in game theory, solving game problems by simplex method.

Books Recommended

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

DSC IX (STS – 10): Linear and Nonlinear Modelling

Course Objectives:

Regression analysis is the most common statistical modelling approach used in data analysis and it is the basis for advanced statistical modelling.

The objective of this course is to impart knowledge about the use of different useful tools used in regression analysis. The relationship between variables can be of different types like linear, nonlinear etc. The relationship is represented in terms of a model. The adequacy of any model can be checked using residual plots and residual analysis. Appropriate statistical tools are required to check for the violations of model assumptions and for dealing with problems of Multicollinearity etc.

Course Outcomes:

At the end of the course, students become well versed with,

1. Linear and Multiple regression.
2. To interpret different types of plots such as residual plots, normal probability plots etc. To check for the violations of model assumptions using residual analysis and other statistical tests.
3. To differentiate between linear and nonlinear regression under given situation.
4. Generalized Linear Models including logistic.

Unit I : :Multiple Linear regression: Model assumptions and checking for the violations of model assumption., Residual analysis – definition of residuals, standardized residuals, residual plots, statistical tests on residuals, Press statistics. Transformation of variables, Box-Cox power transformation .Outliers: Detection and remedial measures, Influential observations: leverage, measures of influence, Cook's D, DFITS AND DFBETAS.

Unit II :Multi co-linearity : Concept and definition of M.C., sources of M.C. consequences of M.C. identification of M.C. using the correlation matrix, VIF remedial measures (collecting additional data, model respecification), concept to fridge regression. Autocorrelation: consequences, Durbin-Watson test, Estimation of parameters in the presence of autocorrelation.

Unit III : Variable selection: Problem of variable selection, criteria for evaluation subset regression models (choosing subsets), coefficient of multiple determination, residual mean square, Mallow's Cp Statistics. Computational Techniques for variable selection-Forward selection, Back ward elimination, stepwise regression.

Non-linear regression: Difference between Linear and Non-Linear Regression Models, transformation to a linear model, Intrinsically linear and non-linear models. Parameter estimation using the Newton-Gauss method, Hypothesis testing.

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 testing using model deviance.

Books recommended

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

DSEIII A (Sts-11): Operations Research

Course Objectives:

Operations research deals with the application of advanced analytical methods which helps in taking better decisions. The course includes advanced techniques that are useful in business, management, industry, project planning etc.

Course Outcomes:

At the end of the course, students become well versed with,

1. Concept of inventory problem, need of inventory and types of inventory models and types of probabilistic inventory models.
2. Sequencing problems and methods to solve sequencing problems in different situations
3. Concept of queues, different types of queues and their analysis.
4. Concept of Networking, CPM, PERT and methods of obtaining optimum solutions to the problems.

Unit I : **Inventory problems** : Structure of inventory problem, EOQ formula, EOQ model with uniform rate of demand & having no shortages, EOQ model with different rate of demand in different cycles having no shortages, EOQ model with uniform rate of demand & finite rate of replenishment having no shortages, EOQ model with uniform rate of demand & finite rate of replenishment having shortages, EOQ model with uniform rate of demand, infinite rate of replenishment having shortages, EOQ model with single & double price breaks.

Unit II: Single period probabilistic inventory models with

i) Instantaneous demand & discrete units
ii) Instantaneous demand & continuous units
iii) Continuous demand & discrete units
iv) Continuous demand & continuous units

Unit III: Processing n jobs through two machines,
Processing n jobs through three machines,
Processing 2 jobs through m machines,
Processing n jobs through m machines,
Traveling salesman problem
Queuing Models: M/M/1 :FCFS/ / & its generalization
M/M/1:FCF/N/M/M/C/ ,
FCFS/M/Ek/1: FCFS/ / ,
/ ,

Unit IV: Networking: Basic steps in PERT & CPM, methods of solving PERT problem, crashing the network, updating (PERT & CPM) max. Flow min. cut theorem, problems based on max. flow min cut theorem.

Books Recommended

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

DSE III B (Sts-12): Bioassay

Course Objectives:

Bio assay is an analytical method to determine concentration of a substance by its effect on living cells tissues, insects, etc. There are various types of Bio assays like qualitative or quantitative, direct or indirect. These analytical methods are useful in environmental science, microbiology etc. The method of dose and response relationship in this analysis is used in pharmaceutical sciences. Objective of this course is to train students in analytical methods used in these fields.

Course Outcomes:

At the end of the course, students become well versed with,

1. Types of biological assays and methods for estimating dose response relationship.
2. Logit and probit approach for estimating dose-response relationship.
3. Methods of estimation of parameters and dose allocation schemes.
4. Sequential procedures, estimation of safe dose, ANOVA and Bayesian approach to Bio assays.

Unit I: Types of biological assays, direct assays, ratio estimators, asymptotic distributions, Fieller's theorem Regression approaches to estimating dose-response relationships, Logit and Probit approaches when dose-response curve for standard preparation is unknown.

Unit II : Methods of estimation of parameters, estimation of extreme quantiles., dose allocation schemes. Quantal Responses, Polychotomous quantal responses. estimation of points on the quantal response function

Unit III: Sequential procedures, estimation of safe doses.

Unit IV: ANOVA and Bayesian approach to Bio assay

Books Recommended

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. Thiemann: Introduction to Biotechnology Pearson

DSE III C (Sts-13): Econometrics

Course Objective

The purpose of this course is to give students a solid foundation in econometric techniques, various functions for economic analysis and future forecasting.

Course Outcomes

On completion of this course, students will be able to:

1: Understand the basic concepts of econometric models.

2: Learn knowledge of various econometric models, estimation methods and related econometric theories.

3: Understand the statistical techniques to model relationships between variables and make predictions.

4: Learn how to conduct econometric analysis of data.

Unit I :

Introduction to econometrics. A review of least squares and maximum likelihood estimation methods of parameters in classical linear regression model and their properties. Generalized least squares estimation and prediction, construction of confidence regions and tests of hypotheses. Regression analysis under linear restrictions, restricted least squares estimation method and its properties. Autocorrelation, sources and consequences, Autoregressive process tests for autocorrelation, Durbin Watson test.

Unit II:

Problem of Multi collinearity, its implications. Source of multi collinearity, tools for handling the problem of multi collinearity. Remedies for multi collinearity. Ridge regression. Heteroskedasticity, consequences and tests for it, estimation procedures under Heteroskedastic disturbances, Bartlett's test, Breusch Pagan test and Goldfelf Quandt test, Dummy Variable Models.

Unit III:

Specification Error Analysis, Tests for Structural Change and Stability, Asymptotictheoryandregressors.Stein-RuleEstimation.Instrumentalvariableestimation.Measurement Error Models.

Unit IV:

Simultaneous equations model, problem of identification, necessary and sufficient condition for the identifiability of parameters in a structuralequation,ordinaryleastsquares,indirectleastsquares,two-stageleast squares and limited information maximum Likelihood method.

Books Recommended

1. Gujrati, D.N. &Porter, D.C. (2017).BasicEconometrics,6th Edition. McGraw-Hill.
2. Maddala, G.S. & Lahiri, K. (2010).Introduction to Econometrics, 4thEdition.Wiley.
3. Greene, W.H. (2012).Econometric Analysis, 7th Edition .Pearson.
4. Studenmund, A.H. & Johnson, B.K. (2017).Using Econometrics: A Practical Guide,7thEdition.Pearson.

DSE III D (Sts-14): Actuarial Statistics

Course Objectives:

Actuarial science includes statistical methods to assess risk mainly in insurance and finance. The course includes these statistical methods based on probability theory and stochastic models. Objective here is to make the students aware about this important branch of statistics.

Course Outcomes:

At the end of the course, students become well versed with,

1. Concept of inventory problem, need of inventory and types of inventory models and types of probabilistic inventory models.
2. Sequencing problems and methods to solve sequencing problems in different situations
3. Concept of queues, different types of queues and their analysis.
4. Concept of Networking, CPM, PERT and methods of obtaining optimum solutions to the problems.

Unit I:

Life table and its relation with survival function, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. Multiple life functions, joint and last survivor status, insurance and annuity benefits through multiple life functions. Multiple decrement models, deterministic and random survivor groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical valuations.

Unit II:

Principals of compound interest: Nominal and effective rates of interest and discount, fore of interest and discount,compoundinterest,accumulationfactor,continuouscompounding.Life insurance : 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, recursion, commutation functions.

Unit III: Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursion, and complete annuities-immediate and apportionable annuities-due. Net premiums: Continuous and discrete premiums, true monthly payments premiums, apportionable premiums, commutation functions, accumulation type benefits.

Unit IV:

Net premium reserves: Continuous and discrete net premium reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional duration, allocations of loss to policy years, recursive formulas and d differential equations for reserves, commutation functions. Some practical considerations: Premiums that include expenses–general expenses, types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

Books Recommended

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 Nirali Prakashan
4. Swiss Re: Statistical foundations of Actuarial Learning and its applications Springer

LAB I: Practicals Based on DSC VII and DSC VIII

LAB II : Practicals Based on DSC IX and DSEIII

DSCX(Sts-15): Computational Statistics

Course Objectives:

In many disciplines, results are established with the help of the data by fitting a suitable model . Analyzing the data plays an important role in such cases. Advanced statistical methods and different types of models can be applied to these data, even very big data .The course deals with different computational methods and algorithms necessary for analysis of the data. The course includes different methods that are particularly useful in simulating data from various distributions and analyzing them with the help of computers.

Course Outcomes:

At the end of the course, students become well versed with,

1. Visualization of data and exploratory data analysis.
2. Stochastic simulation techniques like MCMC.
3. Some important methods of handling missing data and incomplete data problems like EM algorithm etc.
4. Jackknife ,Bootstarp and nonparametric density estimation using kernels.

Unit I :

Exploratory data analysis: Components of EDA ,transforming data, Clustering: Similarity measures, similarity coefficients, Hierarchical clustering methods: single, complete and average linkage methods, dendrograms, Graphical Methods: Quintile plots, Box Plots, Histogram, Stem & leaf diagram, Q-Q plots, P-P plots

Unit II:

Stochastic simulation: generating random variables from discrete and continuous distributions, simulation bivariate/multivariate distributions, simulating stochastic processes such as simple queues. Variance reduction technique: Importance sampling for integration, control variates, antithetic variables. MCMC methods : Essence of MCMC methods, Time reversible MC, Law of large numbers for MC. Metropolis-Hastings algorithm, Gibbs sampling for bivariate/multivariate simulation. Simulated annealing for optimization, simulated annealing for M.C. Simulation based testing: simulating test statistics and power functions, permutation/randomization tests.

Unit III:

Resampling paradigms: Jackknife and Bootstrap: Delete one J-K,pseudovalues, Bias and S.E. Efron's bootstrap, Bootstrap C.I. Bootstrap-t C.I, Bootstrap C.I. (percentile method),Bootstrap in regression, Bootstrap C.I.for linear regression parameters.

Unit IV:

EM algorithm: Application to missing and incomplete data problems. Mixture models. Smoothing with Kernels: Density estimation, kernel density estimator for univariate data, Band width selection and cross validation, Max likelihood LCV, Least square CV.

Books Recommended

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) (CBCS Pattern) SIV

AEC on DSCX

Applications of Monte Carlo Simulations

Syllabus

Simulation of sample paths of stochastic process: in particular Brownian motion and Poisson process

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

DSC XI (Sts-16): Multivariate Analysis

Course Objective

The main objective of this course is to introduce students to the analysis of observations on several correlated random variables for a number of individuals. Multivariate analysis is applicable in almost all scientific studies, for example in Anthropology, Life sciences, Agriculture and Economics, when one deals with several variables simultaneously.

Course Outcome

After completing this course, student is expected to learn the following:

1Account for important theorems and concepts in multivariate analysis.

2Understand the concept of Wishart andHotelling's T^2distribution.

3Understand the link between multivariate techniques and corresponding univariate techniques.

4Conduct statistical inference about multivariate means including hypothesis testing, Confidence region calculation, etc.

Unit I:

Multivariate normal distribution, its properties and characterization. Random sampling from a multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector. Inference concerning the mean vector when the covariance matrix is known. Matrix normal distribution. Multivariate central limit theorem.

Unit II:

Wishart matrix, its distribution and properties. Distribution of sample generalized variance. Hotelling's T^2 statistic and its distribution and properties. Applications in tests on mean vector for one and more multivariate normal populations. Mahalanobis' D^2.

Unit III:

Likelihood ratio test criteria for testing of independence of sets of variables, equality of covariance matrices, identity of several multivariate normal populations, equality of a covariance matrix to a given matrix, equality of a mean vector And a covariance matrix to a given vector and a given matrix

Unit IV:

Classification and discrimination procedures for discrimination between two multivariate normal populations, sample discriminant function, tests associated with discriminant functions, classification into more than two multivariate normal populations. Principal components, canonical variables and canonical correlations. Multivariate analysis of variance [MANOVA] of one-way classified data. Wilk's lambda criterion.

Books Recommended

1. Johnson, R.A.and Wichern, D.W. (2015): Applied Multivariate Statistical Analysis, Sixth Edition, Pearson Education India.
2. Hardle, W.K.and Hlavka, Z. (2015): Multivariate Statistics, Springer.
3. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, Third Edition, Wiley.
4. Härdle, W.K.and Simar, L. (2015): Applied Multivariate Statistical Analysis, Springer.
5. Singh, B.M. (2004): Multivariate statistical analysis, South Asian Publishers.

M.Sc. II (Statistics) (CBCS Pattern) Semester IV

DSC XII (Sts-17): Stochastic Process

Course Objective

The objective of this course is to apprise the students with the basic concepts of the theory of stochastic processes in continuous time, also to make them able to use various analytical and computational techniques to study stochastic models that appears in applications.

Course Outcomes

After completing this course, student is expected to learn the following:

1 Study the fundamental concept of stochastic processes and its applications.

2 Understand Markov processes and Markov chains and their applications in real world.

3 Study the branching process and its properties.

4 Understand Poisson processes and its variations.

Unit I: Stochastic Processes: Introduction, classification according to state space and time domain. Countable state Markov chains, transition probability matrix, Chapman-Kolmogorov equations, calculation of n-step transition probabilities and their limits, Stationary distribution.

Unit II:

Branching Processes: Properties of generating function of branching processes, probability of ultimate extinction, distribution of the total number of progeny, generalization of the classical Galton-Watson branching process, general branching processes, random walk and gambler's ruin problem.

Unit III:

Continuous-time Markov Processes: Poisson process and related distributions, generalizations of Poisson process, simple birth-process, simple death-process, simple birth-death process, linear birth-death process. First passage time distribution.

Unit IV:

Renewal Theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem, central limit theorem for renewals, study of residual and excess life time's process. Renewal reward Process, Markov renewal and semi- Markov processes, Markov renewal equations.

Books Recommended

1. Medhi, J. (2012).Stochastic Processes, 3rdEdition.New Age International.
2. Ross, S.M. (2016). StochasticProcesses, 2ndEdition.WileyIndia.
3. Karlin, S. &Taylor, H.M. (2012).A First Course in Stochastic Processes, 2nd Edition. Academic Press.
4. Prabhu, N.U. (2010).Stochastic Processes: Basic Theory and its Applications. World Scientific.

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

DSEIVA (Sts-18): Bayesian Inference

Course Objective

The objective of this course is to provide the understanding of the decision theory and fundamentals of Bayesian inference including concept of subjectivity and priors by examining some simple Bayesian frame work.

Course Outcomes

After successful completion of this course, student will be able to:

1. To understand and utilize past experience along with present observation and improve the inferences.
2. Equip students with skills to carry out and interpret posterior data-based modeling and analyses.
3. Understand Decision theoretical concepts, game theory and their applications.

4. To understand the Bayesian estimation and testing procedures and compare them with classical inference.

Unit I:

Bayes Rule, extended Bayes rule, Minimax rule, methods for finding minimax rules, Generalized Bayes and limit of Bayes rule, Concept of admissibility and completeness Bayes rules, Admissibility of Bayes and minimax rules, Supporting and separating hyper plane theorems, complete class theorem ,Minimax estimators of Normal and Poisson means.

Unit II:

Subjective interpretation of probability in terms of fair odds, Evaluation of (i) subjective probability of an event using a subjectively unbiased coin (ii) subjective prior distribution of a parameter, Bayes theorem and computation of the posterior distribution, Natural Conjugate family of priors for a model, Hyper parameters of a prior from conjugate family

Unit III:

Bayesian point estimation as a prediction problem from posterior distribution, Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0 -1 loss, Bayesian interval estimation: credible intervals, highest posterior density regions

Unit IV: Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval, Bayesian Testing Hypothesis: Specification of the appropriate from of the prior distribution for a Bayesian testing of hypothesis problem, Prior odds, Posterior odds, Bayes factor.

Books Recommended

1. James O Berger (1985): Statistical Decision Theory and Bayesian analysis. Springer.
2. Ferguson T.S. (1967): Mathematical Statistics-A decisions theoretic Approach. Academic Press.
3. DeGroot. M.H.: Optimal Statistical Decisions. McGraw-Hill.
4. Leonard T and Hsu J.S.J.: Bayesian Methods. Cambridge University Press.
5. Bernardo, J. M. and Smith AFM: Bayesian Theory. John Willey.
6. Rao, C. R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
7. Robert, C. P.: The Bayesian Choice :A Decision Theoretic Motivation, Springe

M.Sc. II (Statistics) (CBCS Pattern) Semester IV

DSE IV B (Sts-19): Statistical Ecology

Course Objectives:

Ecology is study of interaction of organisms that include biotic and a biotic components and their environment. Ecologists can explain life processes, interactions, adoptions, movement of materials, distribution of organisms, biodiversity etc. by using various statistical methods. The course gives knowledge of these methods and models in this particular branch.

Course Outcomes:

At the end of the course, students become well versed with,

1. Concept of inventory problem, need of inventory and types of inventory models and types of probabilistic inventory models.
2. Sequencing problems and methods to solve sequencing problems in different situations
3. Concept of queues, different types of queues and their analysis.
4. Concept of Networking, CPM, PERT and methods of obtaining optimum solutions to the problems.

Unit I:

Population Dynamics One species exponential, logistic and Gompertz models, Two species competition, co-existence, predator prey oscillation, Lotka-Volterra Equations, isoclines, Lestie matrix model for age structured populations. Survivorship curves constant hazard rate, monotone hazard rate and bath tub shaped hazard rates

Unit II: Population density estimation: Capture recapture models, nearest neighbor models, Line transect sampling, Ecological Diversin, Simpson's index, Diversity as average rarity

Unit III: Optimal Harvesting of Natural Resources, Maximum Sustainable field, tragedy of the commons Game theory in ecology, concepts of evolutionarily stable strategy, its Properties, simple cases such as Hawk-Dovegeme.

Unit IV: Foraging Theory: Diet choice Problem, patch choice problem mean variance tradeoff.

Books Recommended

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

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

DSE IV C (Sts-20): Regression Analysis

Course Objective

The objectives of this course are to develop theoretical foundation of regression models and understand fundamental concepts of regression analysis.

Course Outcome

On completion of this course, students will be able to:
1Understand simple and multiple linear regression models with their applications.
2 Learn the fitting of these models to simulated and real data sets.
3Learn model adequacy using classical diagnostics, awareness of potential problems (outliers, etc.) and application of remedies to deal with them.
4Understand the basic concepts of logistic, Poisson and generalized linear models.

Unit I:

Simple Linear Regression: Simple linear regression model. Least-squares estimation of parameters. Hypothesis testing on the slope and intercept. Interval estimation in simple linear regression. Prediction of new observations. Coefficient of determination. Estimation by maximum likelihood. Multiple linear regression: Multiple linear regression models. Estimation of the model parameters. Hypothesis testing in multiple linear regression. Confidence intervals in multiple regression. Coefficient of determination and Adjusted R^2.

Unit II:

Model Adequacy: Checking of linearity between study and explanatory variable, Residual Analysis, Detection and treatment of outliers, Residual plots. The PRESS statistic. Outlier test

based on Studentized Residual (R-student). Test for lack of fit of the regression model. Transformation and Weighting to Correct Model Inadequacies: Variance stabilizing transformations. Transformations to linearize the model. Analytical
Methods for selecting a transformation on study variable.

Unit III:
Generalized and weighted least square estimation. Polynomial Regression Models: Polynomial models in one variable. Orthogonal Polynomials. Piece wise polynomial (Splines). Variable Selection and Model Building: Incorrect model specifications. Evaluation of subset
Regression model. Computational techniques for variable selection.

Unit IV:
Logistic and Poisson regression models: Introduction, Linear predictor and link functions, logit, probit, odds ratio, maximum likelihood estimation, test of hypothesis. Generalized linear models: Exponential family of distribution, linear predictors and link functions, Maximum likelihood estimation of GLM. Prediction and confidence interval with GLM.

Books Recommended

1. Montegomery, D.C., Peck, E.A. & Vining, G.G. (2015).Introduction to Linear Regression Analysis, 5th Edition. Wiley.
2. Rao, C.R. (2009).Linear Statistical Inference and its Applications, 2ndEdition.Wiley.
3. Draper, N.R. & Smith, H. (2011).AppliedRegressionAnalysis,3rd Edition. Wiley.
4. Chatterjee, S.andHadi, A.S. (2012).RegressionAnalysisbyExample,5thEdition.Wiley.
5. Fox, J.and Weisberg, S. (2019).An R Companion to Applied Regression,3rd Edition. Sage Publications

M.Sc. II (Statistics) (CBCS Pattern) Semester IV

DSE IV D (Sts-21): Reliability Theory

Course Objectives:

Manmade systems suffer from imperfections for several reasons. Often these imperfections lead to improper functioning resulting in failure of the system. It may be the result of defect in the system while producing it or may be because of natural component deterioration on some interacting factors. Probability of non-failure is termed as reliability. Reliability models can be developed for predicting the reliability of a component or of system prior to its implementation.

Course Outcomes:

At the end of the course, students become well versed with,

1. Failure time distribution, reliability function, hazard function etc.
2. Increasing failure rate as an effect of ageing, shock models.
3. Reliability estimation in various cases.
4. Reliability growth models.

Unit I:

Reliability concepts and measures ,components and systems, coherent systems, reliability of coherent systems, cuts and paths, modular compositions, bounds on system reliability, structural and reliability importance of components. Life distributions, reliability functions, hazard rate, common life distributions, exponential, Gamma, Weibull, Log normal etc. Estimation of parameters, confidence intervals, L R and MLE tests for these distributions.

Unit II:

Notions of ageing: IFR, IFRA, NBU, DMRL and NBUE classes and their duals, loss of memory property of the exponential distribution, closures of these classes under formation of coherent systems, convolutions and mixtures. Univariate shock models and life distributions arising out of them, bivariate shock model, common bivariate exponential distributions and their properties.

Unit III:

Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items, stress and strength reliability and its estimation. A maintenance and replacement policies, availability of repairable systems, modeling of repairable system by a non-homogeneous Poisson process

Unit IV:

Reliability growth models, probability plotting techniques, Hollander-Proschan and Deshpande tests for exponentially, tests for HPP vs. NHPP with repairable systems.

Books Recommended

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

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

LAB I : Practical based on DSC-X & DSC-XI

LAB II : Practical based on DSC-XII & DSE-IV