Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous),

Shivajinagar, Pune 5

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Syllabus For

M.Sc. Semester III and IV

(Based on NEP 2020 framework)

(To be implemented from the Academic Year 2023-24

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5
PG Part-2 (Semester III), M.Sc. (Statistics)
(2023 Course under NEP 2020)

Course Code: 23ScStaP311 **Course Name: Design of Experiments**
Teaching Scheme: 4 Hours/Week **Credit: 4**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Pre-requisites:

- Basic concepts from linear algebra and probability distributions.

Course Objective:

1. Illustrate basic concepts of design of experiments.
2. Learn the concept of BIBD, connectedness, balancedness and orthogonality of design.
3. Differentiate between fixed and random effect models.
4. Compare the pairs of treatment means using different methods.
5. Perform the analysis of full factorial experiments.
6. Construct fractional factorial experiments and apply confounding in real life problems.
7. Perform ANOCOVA (Analysis of Covariance).

Course Contents

Unit 1	18 lectures
	• One way classification with equal and unequal number of observations per cell, a. Tests for pairwise comparison- Fisher's LSD Method, Tukey's Test, Newman Keuls Test, Duncans Multiple Range Test (DMRT), Dunnet test. b. Tests for assumptions: Levene's test, Bartlet's test. c. Non Parametric Tests : One way ANOVA (Kruskal Wallis Test), Friedman test (Non-parametric alternative to the one-way ANOVA with repeated measures). • Two way classification with equal number of observations per cell (with and without interaction). • Random effect models a. For one factor, estimation of variance components and confidence interval for intra class correlation coefficient. b. For two factors, estimation of variance components • Split Plot Design. • General Block Design – Connectedness, variance balanced and orthogonality of a design.
Unit 2	18 lectures
	a. Balanced Incomplete Block Design (v,b,k,r,λ) b. Necessary and sufficient conditions for existence of BIBD (with Proof). c. Properties of (v,b,k,r,λ). d. Definition of symmetric BIBD, resolvable BIBD, affine resolvable design.

	e. Analysis of BIBD (Intra block analysis.) f. Connectedness, balancedness and orthogonality of a BIBD . • PBIBD with 2 associate classes (PBIBD(2)). • 2^k full factorial experiments: a. Diagrammatic representation of main effects, and first and second order interactions. b. Statistical analysis of 2^2 ,2^3 factorial experiment. Statistical analysis of general 2^k factorial experiment. • Concept of Confounding. a. Total and partial confounding of 2^k design in two blocks. b. Total confounding of 2^k design in 2^p blocks $p \geq 2$, partial confounding in 2^p blocks; p = 2, 3.
Unit 3	18 lectures
	• Fractional factorial experiments a. Resolution of a design (III, IV & V), b. Aberration of a design. • Plackett-Burman designs. a. Introduction. b. Construction of Plackett Burman designs. c. Introduction to Regression Approach to obtain the Alias relationships. • 3^2 factorial designs: a. Contrasts for linear and quadratic effects, statistical analysis of 3^2 design, 3^3 designs: contrasts for linear and quadratic effects. b. Statistical analysis of 3^3 design. c. Blocking of 3^2 in three blocks, blocking of 3^3 in 9 blocks. • Fractional factorial experiment in 3^p designs in $p = 2, 3$.
Unit 4	6 lectures
	• Analysis of Covariance (ANCOVA) . a. Analysis of Covariates. b. Introducing Factorial Experiments with Covariates.

Books Recommended:

1. Dean, A. and Voss, D. (1999).*Design and Analysis of Experiments*, Springer.
2. George E. P. Box, Draper N.R. (1987). *Empirical Model-Building and Response Surfaces*,Wiley.
3. Chakrabarty.M.C.,Mathematics of Design and analysis of experiments.
4. Aloke Dey, Theory of Block Design.
5. Hicks, C.R., Kenneth V. and Turner, Jr. (1999). *Fundamental Concepts in the Design of Experiments*, Oxford UniversityPress.
6. John P.W.M. (1971). *Linear Models*,Wiley.
7. Kshirsagar A.M. (1983). *Linear Models*, Marcel Dekker
8. Montgomery, D.C. (2001). *Design and Analysis of Experiments*,Wiley.
9. Ogawa J. (1974). *Statistical Theory of the Analysis of Experimental Design*, Marcel Dekker.

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PG Part-2 (Semester III), M.Sc. (Statistics)

(2023 Course under NEP 2020)

Course Code: 23ScStaP312 **Course Name: Asymptotic Inference**

Teaching Scheme: 4 Hours/Week **Credit: 4**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Pre-requisites:

- Concepts of Convergence in probability, convergence in distribution.
- Taylor's theorem, mean value theorem.
- Basic probability distributions.

Course Objectives:

1. To derive distributions in statistics in cases where the exact distribution is unavailable.
2. To understand the concept of consistency and asymptotic normality.
3. To study method of moments and percentiles, maximum likelihood to find consistent estimator and Cramer Huzurbazar theorem.
4. To study asymptotic confidence interval.
5. To apply likelihood ratio tests, Wald, Score and Bartlett's test in real life situations.
6. Compare various tests through relative asymptotic efficiency.

Course Contents

Unit 1		24 lectures
	Consistency: real and vector parameters, invariance under continuous transformation; Methods of obtaining consistent estimators: method of moments, method of percentiles, mean squared error criterion; Asymptotic relative efficiency, Comparison of consistent estimators, minimum sample size required by the estimator to attain certain level of accuracy, Asymptotic Normality; Consistent Asymptotic Normal (CAN) estimators: real and vector parameters; invariance of CAN property under non vanishing differentiable transformation. Methods of obtaining CAN estimators: method of moments and method of percentiles.	
Unit 2		18 lectures
	Maximum likelihood estimation, restricted parameter space, Inconsistent MLEs, MLEs in irregular cases. Asymptotic distribution of MLE in special class of distributions: Cramer regularity conditions, Cramer- Huzurbazar theorem, Extension to vector-valued parameters,	

	Super-efficient estimators, BAN estimators, CAN estimation for multi-parameter exponential family and applications, Solution of likelihood equations, Method of scoring, Newton-Raphson and other iterative procedures.	
Unit 3		18 lectures
	Asymptotic theory of tests of hypotheses: Tests based on MLEs, Likelihood Ratio Test (LRT), asymptotic distribution of LRT statistic, Wald Test, Rao's scoret est, Pearson Chi-square test for goodness of fit, Bartlett's test for homogeneity of variances, locally most powerful tests. applications to categorical data analysis , Three dimensional contingency tables. Variance stabilizing transformations (VST): their existence, their applications in obtaining large sample tests and estimators. Asymptotic Confidence Intervals: based on CAN estimators, based on VST. Asymptotic Confidence regions in multi-parameter families.	

Books Recommended:

1. Kale, B.K. and K. Muralidharan (2015), Parametric Inference: An Introduction, Alpha Science Intl Ltd.
2. Gupta Anirban Das (2008), Asymptotic Theory of Statistics and Probability, Springer, New York.
3. Manoj Kumar Srivastava, Abdul Hamid Khan and NamitaSrivastava (2014), Statistical Inference: Theory of Estimation, PHI Learning Pvt Ltd, Delhi.
4. Bolstad W. M. (2007) Introduction to Bayesian Statistics 2nd Ed. Wiley, New York.
5. Lee P.M. (2004) Bayesian Statistics: An Introduction, Hodder Arnold, New York.
6. Ferguson, T.S. (1996), A course on Large Sample Theory. Chapman and Hall, London.
7. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley, New York.
8. Lehmann, E.L. and Casella G. (1999), Theory of Point Estimation, Springer, New York.

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PG Part-2 (Semester III), M.Sc. (Statistics)

(2023 Course under NEP 2020)

Course Code: 23ScStaP313 **Course Name: Time Series Analysis**

Teaching Scheme: 4 Hours/Week **Credit: 4**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Pre-requisites:

- Knowledge of basic concepts of regression theory and multivariate analysis

Course Objectives:

1. Define the time series with it components.
2. Estimate and eliminate trend and seasonality from time series.
3. Examine the time series processes as causal, non-causal, stationary and invertible process.
4. Illustrate AR, MA, ARMA, ARIMA, SARIMA models.
5. Validate and check models with its residual analysis and diagnostic checking.
6. Build Multivariate time series models.

Unit 1		15 lectures
	• Time series as a discrete parameter stochastic process. Exploratory time Series analysis. • Auto covariance and autocorrelation functions and their properties. • Methods of estimation and elimination of trend and seasonality: Graphical method, Moving average, exponential smoothing and least square method. • Testing the estimated noise sequence: The sample ACF, the Portmanteau tests, the turning point test, the difference sign test and the rank test. • Holt - Winters smoothing. Forecasting based on smoothing, adaptive smoothing.	
Unit 2		15 lectures
	• Stationary processes: General linear processes, moving average (MA), auto regressive (AR) and autoregressive moving average (ARMA) processes. • Causal and non-causal process, Stationarity and inevitability conditions. Non-stationary and seasonal time series models: • Auto regressive integrated moving average (ARIMA) models, Seasonal ARIMA (SARIMA) models.	

Unit 3		15 lectures
	• Forecasting in time series models. a) Durbin-Levinson algorithm (without proof). b) Innovation algorithm (without proof). • Estimation of mean, auto covariance and autocorrelation functions. Yule-Walker estimation. Estimation of ARIMA models parameters, maximum likelihood method, large sample theory (without proofs). • Choice of AR and MA periods, FPE, AIC, AICc, BIC, residual analysis and diagnostic checking. • Unit-root tests (Dickey-Fuller).	
Unit 4		15 lectures
	• Spectral analysis of Time Series. • Multivariate Time series model. • VAR(Vector Autoregressive) models, vector ARMA models. • Conditional heteroschedastic models, ARCH and GARCH, properties, examples, estimation & forecasting, extensions of ARCH & GARCH.	

Books Recommended:

1. Brockwell, P.J. and Davis, R. A. Introduction to Time Series Analysis and forecasting., Springer Texts in Statistics.
2. Chatfield, C. (2001). Time Series Forecasting, Chapmann &Hall/CRC, London
3. Fuller, W. A. (1996). Introduction to Statistical Time Series, 2nd Ed. John Wiley,
4. Hamilton N. Y. (1994). Time Series Analysis, Princeton University press. Princeton
5. Kendall, Sir Maurice and Ord, J. K. (1990). Time Series (Third Edition), Edward Arnold.
6. Lutkepohl, H. and Kratzing, M. (Ed.) (2004). Applied Time Series Econometrics, Cambridge University Press, Cambridge
7. Shumway, R. H.andStoffer D. S. (2010) Time Series Analysis & Its Applications, Springer, New York.
8. Tsay, R. S. (2010). Analysis of Financial Time Series ,Wiley Series in Probability and Statistics.
9. Box, Jenkin ,Introduction to Time Series Analysis, Wiley Series in Probability and Statistics.
10. Brockwell Davis ,Time Series: Theory and Methods, Springer series in Statistics .
11. Shumway .R.H and Stoffer .D.S ,Time Series Analysis and its Applications.

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PG Part-2 (Semester III), M.Sc. (Statistics)

(2023 Course under NEP 2020)

Course Code: 23ScStaP314

Course Name: Lab Course on 23ScStaP311, 23ScStaP312 and 23ScStaP313

Teaching Scheme: 4 Hours/Week **Credit: 2**

Examination Scheme CIA 25 Marks **End Sem 25 Marks**

Prerequisites:

- Knowledge of MS-Office, R software, Minitab, ITSM.
- Theory of design of experiments.

Course Objectives:

1. Perform analysis of one way and two way classification.
2. Perform analysis of BIBD
3. Perform analysis of covariance in one way and two way models.
4. Analyze factorial experiments.
5. Calculating and plotting ACF,ACVF amd PACF
6. Choose order in time series. Use ACF/PACF and AIC,BIC
7. Simulate AR,MA,ARMA processes.
8. Predict using fitted linear models. Holt-Winters forecast.

1. Analysis of one way classification (Fixed Effects model) ,Multiple comparison tests.
2. Analysis of one way classification (Random effect model with one factor) , estimation of variance.
3. Analysis of two way classification with equal number of observations per cell (with interaction) and unequal number of observations per cell (without interaction).
4. Analysis of Balanced Incomplete Block Design (BIBD).
5. Analysis of Covariance (ANCOVA) in one way and two way model.
6. a) 2^k Factorial Experiments, analysis of single replicate of 2^k factorial experiments.
   b) Total and partial confounding in 2^k factorial experiments.
7. Analysis of 3^k factorial experiments.
8. Smoothing the series using various Filters and estimation of trend and seasonal component.
9. Calculating and plotting ACF and ACVF.
10. Simulation of AR and MA models and Fitting of AR, MA models.
11. Fitting of ARMA , ARIMA,SARIMA.
12. Forecasting using Holt Winter's method.
13. Fitting heteroscedastic models: Checking for heteroscedasticity from residuals , ARCH,GARCH modeling.
14. Verification of consistency and asymptotic normality of the estimators.
15. Power functions and comparison of tests & confidence intervals (LR, Wald, Score Tests).

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PG Part-2 (Semester III), M.Sc. (Statistics)

(2023 Course under NEP 2020)

Course Code: 23ScStaP321

Course Name: Data Mining (Machine Learning)

Teaching Scheme: 4 Hours/Week **Credit: 4**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Pre-requisites:

- Knowledge of basic probability concepts and standard probability distributions.
- Basic concepts of Multivariate analysis and non-linear programming.
- Knowledge of R-language or Python.

Course Objectives: At the end of the course, students will be able to:

1. Understand various machine learning algorithms.
2. Apply appropriate learning algorithm for analyzing data.
3. Use appropriate R-packages for data analysis.
4. Design learning algorithms for new tasks.
5. Learn many other ML techniques
6. Apply appropriate Data management technique

Course Contents

Unit 1	Introduction to Machine learning	15 lectures
	• Need for and meaning of Machine Learning (ML). Various ML tasks. Framework of ML environment. Relationship with other fields such as Data Mining, Statistics, Data Science, Big Data Analytics. • Data preparation for knowledge discovery: Data understanding and data cleaning tools, Data transformation, Data Discretization. • Types of learning - Supervised learning, Unsupervised learning, Semi-supervised learning • Dimensionality reduction-Introduction to dimensionality reduction.	
Unit 2	Supervised Learning	20 lectures

	• Supervised learning • Learning with Classification - Introduction to Classification task and optimality of Bayes rule.Generative and discriminative approaches to classification problem Naïve Bayes classifier, K-Nearest Neighbors,, Linear and non-linear discriminant functions. • Logistic regression, Multi class classification with softmax-activation function. • Decision Tree Learning-Decision Tree Learning – Impurity measures, Gini Index, Cross-Entropy, construction of classification tree, Cost-Complexity pruning, missing data in trees, tree pruning, and modifications for regression trees. • Neural Network Learning - basic concepts, Perceptron learning and its limitations, Back-propagation algorithm. • SupportVectorMachine - SVM Learning. Linear separability. Hard and soft margin optimal decision boundaries. Kernel trick. • Evaluatingmodelperformance-Falsepositives, False negatives Confusion matrix, Accuracy, Precision, Recall, • ClassificationandEvaluationMatrix.	
Unit 3	Unsupervised Learning	15 lectures
	• Un-supervisedlearning • Clustering algorithms-K-means clustering, K medoids clustering, methods for determining optimal number of clusters. • Rule based learning-Association rule mining, Apriori, Support and Confidence parameters and Comparison • Market Basket Analysis and some miscellaneous topics.	
Unit 4	Model Evaluation, Selection and Classification Accuracy	10 lectures
	• Model evaluation and selection: Metrics for • Evaluating Classifier Performance. • Concept of training data, testing data and validation of model, resampling method, Cross-Validation, Bootstrap, Model Selection Using Statistical Tests of Significance. • Techniques to Improve Classification Accuracy: Introduction to Ensemble Methods Bagging. Boosting and Ada Boost, XG Boost, random forests. • Improving Classification Accuracy of Class Imbalanced Data. • Multiple imputation method • Synthetic Minority Oversampling Technique	

There should be Lab work for 12 hours in the entire term where in students get opportunity to test the algorithms using R/ Python/ SQL/Software Packages such as Weka.

Books Recommended:

1. Pang-Ning Tan, Michael Steinbach and Vipin Kumar (2013) Introduction to Data Mining. (Indian Edition) Pearson Education (Published by Dorling Kindersley (India)
2. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani (2013) An Introduction to Statistical Learning: With Applications in R. (Springer)
3. ShaiShalev-Schwartz and Shai Ben-David (2014) Understanding Machine Learning: From Theory to Algorithms (Cambridge University Press)
4. Han J., Kamber M., and Pei J (2012) Data Mining: Concepts and Techniques. (Elsevier)
5. Alex Smola and S.V.N. Vishwanathan (2008) Introduction to Machine Learning. (Third Edition) (Cambridge University Press)
6. Ian H. Witten and Eibe Frank (2005) Data Mining: Practical Machine Learning Tools and Techniques. (Second Edition) (Elsevier)

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PG Part-2 (Semester III), M.Sc. (Statistics)

(2023 Course under NEP 2020)

Course Code: 23ScStaP322 **Course Name: Categorical Data Analysis**

Teaching Scheme: 4 Hours/Week **Credit: 4**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisites:

- Knowledge of basic finite sample inference and asymptotic inference.

Course Objective: After completing the course student will be

1. Define categorical data, contingency tables.
2. Apply probability models to categorical data.
3. Learn advanced methods of modeling data.
4. Learn variety of methods for analyzing data count.
5. Understand the situations where these methods are applicable.
6. Have reasonable grasp of the theoretical foundation of categorical data analysis.

Course Contents:

Unit 1		15 lectures
	Introduction to Categorical data analysis: categorical response data, Probability distributions for categorical data, statistical inference for discrete data Contingency tables: Probability structure for contingency tables, comparing proportions with 2x2 tables, odds ratio, tests for independence, exact inference, extension to three way and larger tables	
Unit 2		15 lectures
	Generalized linear models (GLM): GLM for binary data and count data, Statistical inference and model checking, fitting GLMs Logistic Regression: interpretation, inference, logistic regression with categorical predictors	
Unit 3		15 lectures
	Multiple logistic regression, building and applying logistic regression model, multi category logit models Loglinear models for two way and three way tables, inference for loglinear models, loglinear-logistic connection, independence	

	graphs and collapsibility	
Unit 4		15 lectures
	Models for matched pairs: comparing dependent proportions, logistic regression for matched pairs, comparing margins of square contingency tables Random effects modeling of clustered categorical data, extension to multinomial responses, hierarchial models	

Books Recommended:

1. Agresti, A (2002) Categorical Data Analysis, 2^{nd}edn, New York, Wiley,
2. Agresti, A (2007) An Introduction to Categorical Data Analysis, 2^{nd}edn, New York, Wiley,
3. E.B. Andersen(1990), The Statistical Analysis of Categorical Data, Springer-Verlag
4. T.J. Santner and D. Duffy(1989), The Statistical Analysis of Discrete Data, Springer-Verlag.

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PG Part-2 (Semester IV), M.Sc. (Statistics)

(2023 Course under NEP 2020)

Course Code: 23ScStaP411 | **Course Name: Stochastic Processes**

Teaching Scheme: 4 Hours/Week | **Credit: 4**

Examination Scheme: CIA: 50 Marks | **End-Sem: 50 Marks**

Pre-requisites:

- Knowledge of linear algebra, differential equations

Course Objectives:

Student will be able to

1. Define a stochastic process
2. Differentiate among types of stochastic processes.
3. Apply the concept of stochastic process in real life data.
4. Determine the type of stochastic process for given data set.
5. Estimation of parameters in a stochastic process.
6. Calculate the probabilities of various events.

Course Contents:

Unit 1		15 lectures
	Stochastic processes, Markov property, Markov chains (MC), finite MC, transition probabilities, initial distribution, illustrations such as random walk, Ehrenfest chain, gambler's ruin chain, queuing chain, birth death chain, branching chain, Chapman Kolmogorov equation, n-step transition probabilities, transition probability matrix (t.p.m.) hitting times, probability of ever return, transient and recurrent states, decomposition of state space, closed set of states, irreducible set of states, irreducible MC, absorption probabilities, martingales, classification of states of birth and death chains, branching chain, queuing chain, random walk, gambler's ruin chain with absorbing , reflecting and elastic barrier, etc. probability of ruin cases (i)adversary is infinitely rich (ii) stakes are doubled or halved , expected gain, expected duration of the game.	
Unit 2		15 lectures

	Elementary properties of stationary distributions, illustrations such as birth and death chains, Ehrenfest chain, particles in box, average number of visits to recurrent state, non null and positive recurrent states, probability of absorption in persistent class starting from transient state, period of state, existence of uniqueness of stationary distributions, reducible chains, illustrations such as queuing chain finite chains, convergence to the stationary distribution. Steady state distribution, ergodic Markov chain. Ergodic theorem. **Branching Chain**: BGW branching process, offspring distribution, mean and variance, generating function for probability of ultimate extinction, nth generation size and related recurrence relations	
Unit 3		15 lectures
	Intensity rates, it's relation with transition probabilities. Kolmogorov consistency condition, Markov property in continuous time stochastic processes.Kolmogorov forward and backward equations. **Poisson process**: Postulates and properties of Poisson process, probability distribution of N(t) the number of occurrences of the event in (0,t], Poisson process and probability distribution of interarrival time, generalizations of Poisson process: pure birth process: Yule Furry process. **Renewal process**: renewal process in continuous time, renewal function and renewal density, renewal equation, stopping time: wald's equation, elementary renewal theorem and its applications: (i) Age and block replacement policies, (ii) Replacement on failure and block replacement, renewal theorems (Blackwell's and Smith's): (i) Blackwell's theorems, (ii) Smith's theorem or Key Renewal theorem, Poisson process as renewal process, alternating or two stage renewal process.	
Unit 4		15 lectures
	Birth and death process: (i) PureBirth process (ii)Pure death process, particular cases: Birth immigration process. (i)	

	immigration-emigration process, (ii) linear growth process, (iii) linear growth with immigration, (iv) immigration death process. **Continuous time Markov chains**(CTMC): Chapman Kolmogorov equations, limiting distributions, ergodicity of homogeneous Markov process. (c) Markov processes with continuous state space: Introduction to Brownian motion and its properties, Wiener process.	

Books Recommended:

1. Ross, S. (2000) Introduction to probability models, 7th edition (Academic Press)
2. MedhiJ. (1982) Stochastic processes (Wiley Eastern)
3. Hoel ,P.G.,Port, S.C. ,Stone, C.J. (1972) : Introduction to stochastic processes
4. Bhat, B.R. (2000) stochastic models: Analysis and applications (New Age International)
5. Adke, S.R., Manjunath, S.M. (1984) An introduction to finite Markov processes (Wiley Eastern)
6. Ross, S. (1996) Stochastic processes (John Wiley)
7. Taylor, H N and Karlin, S. (1984) An introduction to stochastic modelling(Academic Press)

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PG Part-2 (Semester IV), M.Sc. (Statistics)
(2023 Course under NEP 2020)

Course Code: 23ScStaP412 | **Course Name: Bayesian Inference**
Teaching Scheme: 4 Hours/Week | **Credit: 4**
Examination Scheme: CIA: 50 Marks | **End-Sem: 50 Marks**

Prerequisites:

- Knowledge of basic probability distributions.

Course Objective:

1. To understand the Bayesian philosophy
2. To understand the difference between classical inference and Bayesian inference.
3. To study point and interval estimation in Bayesian set up.
4. To study Bayesian testing procedures.
5. To study Bayesian computing methods.
6. To apply Bayesian computing methods.

Course Contents

Unit 1		24 lectures
	Bayesian inference set up, prior distributions, posterior distributions, common problems of Bayesian inference, Point estimators, Bayesian HPD confidence intervals, testing, credible intervals, prediction of a future observation, loss function, principle of minimum expected posterior loss, quadratic and other common loss functions	
Unit 2		4 lectures
	Bayesian analysis with subjective prior, conjugate class of priors, Jeffrey's prior, probability matching prior, robustness and sensitivity	
Unit 3		4 lectures
	Bayesian model selection, BIC, Bayes factors, limit of posterior distributions, consistency and asymptotic normality of posterior distributions.	
Unit 4		28 lectures
	Approximate Bayes Computing, E-M Algorithm, MCMC, MH Algorithms , Gibb's sampling , convergence diagnostics. (Note: Minimum 10 hours of computational practice)	

Books Recommended:

1. Bolstad, W. M. (2007). Introduction to Bayesian Statistics, 2nd Edn. Wiley,
2. Christensen R, Johnson, W., Branscum, A. and Hanson T. E. (2011). Bayesian Ideas and Data Analysis: An Introduction for Scientists and Statisticians, Chapman & Hall.
3. Congdon, P. (2006). Bayesian Statistical Modeling, Wiley
4. Ghosh, J. K., Delampady M. and T. Samantha (2006). An Introduction to Bayesian Analysis: Theory & Methods, Springer.
5. Jim, A. (2009). Bayesian Computation with R, 2nd Edn, Springer.
6. Rao. C.R. and Day. D. (2006). Bayesian Thinking, Modeling & Computation, Handbook of Statistics, Vol. 25. Elsevier

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PG Part-2 (Semester IV), M.Sc. (Statistics)
(2023 Course under NEP 2020)

Course Code: 23ScStaP413 **Course Name:** Actuarial Statistics

Teaching Scheme: 4 Hours/Week **Credit: 4**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisites:

- Knowledge of basics of probability and lifetime distributions.

Course Objective:
After completion of the course student will able to:

1. Learn key statistical knowledge and skills needed to analysis and interpret the data associated with insurance.
2. Understand the principles and develop insight behind the different products of life insurances.
3. Use statistical techniques in the analysis, predictions of actuarial data.
4. Calculate certain and life annuities in different scenario.
5. Understand and compute different products of premiums through life insurance.
6. Understand, compute and interpret different products of reserve.

Course Contents

	Title and content	**Lectures**
Unit 1	**Insurance Business**	**4**
	1.1) Insurance companies as business organizations. 1.2) Role of insurance business in Economy. 1.3) Concept of risk, types of risk, characteristics of insurable risk. 1.4) Working of insurance business, introduction of terms such as premium, policy, policyholder and benefit. 1.5) Role of Statistics in insurance. 1.6) Insurance business in India.	
Unit 2	**Feasibility of Insurance Business**	**4**
	2.1) Measurement of adverse financial impact, Expected value principle. 2.2) Concept of utility function 2.3) Feasibility of insurance business. 2.4) Illustrative examples.	

Unit 3	**Survival Distribution and Life Tables**	**12**
	3.1) Time- until death random variable, its d.f. and survival function in actuarial notation. 3.2) Force of mortality, Deferred probability. 3.3) Interrelations among d.f., survival function, force of mortality and p.d.f. 3.4) Curtate future life random variable, its p.m.f. and survival function in actuarial notation. 3.5) Construction of life table.(different terms like l_x, d_x, L_x, T_x, e_x etc.) 3.6) Analytical laws of mortality such as Gompertz' law and Makeham's law, single decrement life table, assumptions for fractional ages, select and ultimate life tables.	
Unit 4	**Models for Life Insurance**	**12**
	4.1) Theory of compound interest, effective rate of interest, discount factor. 4.2) Insurance payable at the moment of death and end of the year of death, present value random variable, actuarial present value and variance 4.3) Derivation of actuarial present values and variances for n-year term life insurance, whole life insurance and endowment insurance. 4.4) Varying benefit insurances	
Unit 5	**Annuities**	**12**
	5.1) Annuities – certain, annuity due, annuity immediate, life annuities continuous annuities, deffered annuities , m^{th} ly annuities 5.2) Discrete and continuous life annuities, present value random variables of the payment, and their actuarial present values of the annuities.	
Unit 6	**Benefit Premiums**	**10**
	6.1) Concept of a loss at issue random variable. 6.2) Principles to calculate premiums 6.3) Computation of fully continuous, fully Discrete, semi- continuous premium for Different insurance and annuity plans. 6.4) Variance of loss random variable	

Unit 7	Reserve	6
	7.1 Concept of reserve, prospective & retrospective approach. 7.2 Fully continuous reserve. Fully discrete reserve. 7.3 examples on reserve calculation	
	Books Recommended: **Text Books:** 1. Deshmukh S.R. (2009). Actuarial Statistics: An Introduction Using R, Universities Press. 2. Deshmukh Shailaja (2012) Multiple Decrement Models in Insurance. An Introduction using R., Springer India . **Reference Books** **1.** Bowers, JR. N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). Actuarial Mathematics, 2nd Edn., The Society of Actuaries. **2.** Harriett, E.J. and Dani, L. L.(1999). Principles of Insurance: Life,Health, and Annuities, 2nd Edn., Life Office Management Association. **3.** Neill, Alistair (1977). Life Contingencies, The Institute of Actuaries. **4.** Palande, P. S., Shah, R. S. and Lunawat, M. L. (2003). Insurance in India - Changing Policies and Emerging Opportunities, Response Books.	

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PG Part-2 (Semester IV), M.Sc. (Statistics)
(2023 Course under NEP 2020)

Course Code: 23ScStaP421
Course Name: Design and Analysis of Clinical Trials
Teaching Scheme: 4 Hours/Week **Credit: 4**
Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**
Pre-requisites:

- Basic understanding of parametric inference, Bayesian inference, non-parametric inference.

Course Objectives:

1. Learn key statistical knowledge and skill needed to analyze and interpret data associated with clinical trials.
2. Understand how to write protocol for clinical trial.
3. Utilize the basic terminology and definitions of clinical trials.
4. Learn how to design clinical trial and analyze the data.
5. Apply various statistical techniques to clinical trial and interpret the result.
6. Understand the concept of bioequivalence and bioavailability.
7. Apply various statistical techniques to estimate parameter of bioequivalence and bioavailability.

Course Contents

Unit 1		15 lectures
	Introduction to clinical trials: need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multicenter trials. Data management: data definitions, case report forms, database design, data collection systems for good clinical practice. Randomization and types of randomization, Bioavailability, pharmacokinetics and pharmacodynamics, two-compartment model.	
Unit 2		15 lectures
	Design of clinical trials: parallel vs. cross-over designs, hybrid design, cross-sectional vs. longitudinal designs, response surface experiments and group allocation design, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials. Design and monitoring of Phase III trials with sequential stopping, design of bio-equivalence trials. Optimal crossover designs: Balaam's design, two-sequence dual design, optimal four period designs, Balance incomplete block design, Williams design.	

Unit 3		15 lectures
	Power and sample size determination, multiplicative (or log-transformed) model, ML method of estimation, assessment of inter and intra subject variabilities, detection of outlying subjects. Analysis of clinical trial when data is censored. Estimation of pharmacokinetic parameter. Analysis of survival data in clinical trial: Kaplan Meier (product limit estimator), log rank test and cox's proportional hazard model with one and several covariates.	
Unit 4		15 lectures
	Designs based on clinical endpoints: Weighted least squares method, log-linear models, generalized estimating equations. Drug interaction study, dose proportionality study, steady state analysis. Assessment of bioequivalence for more than two drugs, Inference for 2x2 crossover design: Classical methods of interval hypothesis testing for bioequivalence, Bayesian methods, nonparametric methods Interim analysis and group sequential tests, alpha spending functions. Analysis of categorical data for one sample and independent sample.	

Books Recommended:

1. Chow S.C. and Liu J.P.(2009). Design and Analysis of Bioavailability and bioequivalence. 3rd Edn. CRC Press.
2. Chow S.C. and Liu J.P. (2004). *Design and Analysis of Clinical Trials*. 2nd Edn. Marcel Dekkar
3. Fleiss J. L.(1989). *The Design and Analysis of Clinical Experiments*. Wiley.
4. Friedman L. M.Furburg C. Demets D. L.(1998). *Fundamentals of Clinical Trials*, Springer.
5. Jennison .C. and Turnbull B. W. (1999). *Group Sequential Methods with Applications to Clinical Trails*, CRC Press.
6. Marubeni .E. and Valsecchi M. G. (1994). *Analyzing Survival Data from Clinical Trials and Observational Studies*, Wiley.

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Shivajinagar, Pune - 5

PG Part-2 (Semester IV), M.Sc. (Statistics)

(2023 Course under NEP 2020)

Course Code: 23ScStaP422 **Course Name: Artificial Intelligence**

Teaching Scheme: 4 Hours/Week **Credit: 4**

Examination Scheme: CIA: 50 Marks **End-Sem: 50 Marks**

Prerequisites:

- Knowledge of basic concepts of parametric inference, regression theory.
- Basic knowledge of computer programming.

Course Objectives:

1. To understand classical and modern AI applications
2. Implement a wide range of AI concepts using Prolog.
3. Understand non-classical AI approaches such as genetic algorithms and neural networks
4. Assess the potential of AI in research and real-world environments
5. Apply data management technique.
6. Perform predictive analysis.

Course Contents:

Unit 1		lectures
	Logic & Theorem Proving, Review prepositional & predicate Calculus, Resolution Production Rules, Procedural versus declarative knowledge, Forward versus backward reasoning, Matching, Control Knowledge Statistical Reasoning, Classical logic versus nonmonotonic logic, Default logic , Circumscription, Fuzzy Logic, Typicality, Levels of confidence, Baye's Theorem, Dempster-Shafer theory of evidence	21
Unit 2		lectures
	Slot & Filler Structures, Semantic nets, Frames, Scripts Learning, Rote Learning, Learning by taking advice, Explanation based learning, Discovery, Analogy.	9
Unit 3		lectures
	Computer Vision, Defining the problem, Overview of solution: Marr's Theory, Early processing: Gray level primal sketch, Primal sketch to 2.5D sketch, Late processing: 2.5D sketch to 3D sketch Natural Language Processing, Defining the problem, Overview of	18

	solution, Syntactic Analysis: Context-free grammars, Transformational grammars, Parsing: Top down, bottom up & chart parsing, Semantics: Thematic roles, Aktionsart, Coercion, Co specification, Extended reasoning with KB, Discourse & Pragmatic Processing: Modeling	
Unit 4		lectures
	Connectionism: Biological basis of connectionism, Historical background to connectionism, McCulloch & Pits formal neuron, Hebbs learning rule, Rosen blatts perception, Associations, Hopfield Networks, Back propagation, Connectionist representations & representational adequacy	12

Books Recommended:

1. S. Russell, P. Norvig (1994); Artificial Intelligence: A modern approach(3rd edition), Prentice Hall
2. E.Rich, K. Knight(1991); Artificial Intelligence, McGraw Hill
3. Phil Picton (2000); Neural Networks, Palgrave
4. J.R. Parker(1996); Algorithms for Image processing & Computer Vision(2nd edition), Wiley
5. C. Rowden (1992); Speech Processing, McGraw Hill